Digital Imaging and Communications in Medicine (DICOM)

Supplement 140: XA/XRF Grayscale Softcopy Presentation State Storage SOP Class

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Scope and Field of Application

This supplement defines a new SOP Class extending the capabilities of the existing GSPS SOP Class with functions specifically used by angiographic applications, e.g.:

- Image subtraction with regional pixel shift
- Shutter and presentation functions for a range of frames instead for the whole image

The Enhanced XA/XRF SOP Class defines an augmented context for acquisition and presentation. However, a comparable context for presentation is missing in the existing GSPS.

For instance the existing GSPS does not allow settings on a per-fame basis of attributes that have been defined per-frame in the image object.

Additionally, viewing applications have increased their presentation capabilities with more complex algorithms and functionality. To support interoperability for these presentation capabilities, GSPS has to support new functionalities.

The only solution today to ensure presentation consistency is to create and send two or more instances of the same X-Ray acquisition with different processing applied to the pixels. This allows full presentation consistency on any viewing application and can support any current and future presentation functionality.

However, this creates at least three problems:

- Increased storage space and network load (up to a Gigabyte per run, uncompressed)
- Retrieving requires loading all instances because the query mechanism generally is not able to differentiate between various versions of processing of an instance.
- Necessity for a Viewing Application to manage two (or more) image objects from the same X-Ray acquisition.

Therefore, more functionality for existing Grayscale Softcopy Presentation State is required. Nevertheless, it might be still desirable for applications to create two or more instances of the same X-Ray acquisition with different processing applied to the pixels for compatibility issues with low-end applications.

Discussion of SOP Class Definition Approach

This supplement adds a domain-specific GSPS SOP Class including existing GSPS functionality plus the additional enhanced presentation functionality.

We considered adding optional modules and attributes to the existing GSPS. This is not a suitable approach to ensure interoperability for presentation consistency since optional modules and attributes are not required to be supported by a SCP.

Within WG-02's limited domain the applications are quite specific. It is very likely that they are supported by the equipment used within this domain and persistent storage is required. On the other hand, it is quite unlikely that general purpose equipment implements support for these specific settings.

Discussion of Functional Groups grouping of properties versus GSPS sequences

This supplement defines a new SOP Class by re-using modules of the existing GSPS SOP Class and adding with new modules. The alternative of introducing a new mechanism using the Functional Group sequences was considered and rejected.

The two approaches compared:

1. **Functional Group approach:** Each property or set of properties is stored in a functional group and these functional groups are items of either the Common Functional Group Sequence or the Per-frame Functional Group Sequence. This mechanism is similar to the Functional Groups from the enhanced family of SOP Classes.

   The advantages of this approach are the reuse of the mechanisms defined for the enhanced SOP Classes, reuse of existing Functional Group macros and potentially the use of the Multi-frame Dimension module.

   The disadvantage is the way the functional groups are packed into the Per-frame Functional Group Sequence. For each frame of the image where the presentation state instance is applicable an item must be present, either filled with values or an empty item.

2. **GSPS sequences approach:** The current presentation state contains sequences for a particular presentation function (e.g., VOI LUT) that contains the SOP Class UID, SOP Instance UID and optionally the range of frame numbers for which the presentation information is intended.

   The advantage of this approach is reusing the existing mechanisms used for the GSPS SOP Classes and not introducing another mechanism (the functional groups). A second advantage is to limit the set of presentation parameters to only the frames addressed in the items of the sequences, no dummy items are needed.

   The disadvantage is that it is a different mechanism than used in the enhanced image SOP Classes and does not allow the use of the Dimension module.

Based on an estimate of the number of attributes of a SOP Instance created using both methods of storing the presentation information is calculated. When the presentation settings that change affect less than every four frames the second method is more efficient. When the presentation settings change per frame the size applying the first method is one quarter of the number of attributes compared with the second method.

Typically the cases with XA SOP Instances presentation settings are applied to groups of frames.

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138 # Changes to NEMA Standards Publication PS 3.2-2008

Digital Imaging and Communications in Medicine (DICOM)

140 # Part 2: Conformance

142 **Item #1: Add SOP Class to Table A.1-2**

144 **Table A.1-2**
UID VALUES

UID Value	UID NAME	Category
…		
1.2.840.10008.5.1.4.1.1.11.5	**XA/XRF Grayscale Softcopy Presentation State Storage**	**Transfer**
…		

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Changes to NEMA Standards Publication PS 3.3-2008

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Part 3: Information Object Definitions

158

160 **Item #2: Add in Section A.1.4, Table A.1-4**

A.1.4 Overview of the Composite IOD Module Content

162 Add the following column to table A.1-1.

IODs Modules	XA/XRF Presentation State
Patient	**M**
Clinical Trial Subject	**U**
General Study	**M**
Patient Study	**U**
Clinical Trial Study	**U**
General Series	**M**
Clinical Trial Series	**U**
Presentation Series	**M**
General Equipment	**M**
Enhanced General Equipment	**M**
Bitmap Display Shutter	**C**
Overlay Plane	**C**
Displayed Area	**M**
Overlay Activation	**C**
Graphic Annotation	**C**
Spatial Transformation	**C**
Graphic Layer	**C**
Softcopy VOI LUT	**C**

Presentation State Identification	**M**
Presentation State Relationship	**M**
Presentation State Shutter	**M**
XA/XRF Presentation State Mask Module	**C**
XA/XRF Presentation State Shutter Module	**C**
XA/XRF Presentation State Presentation Module	**C**
Softcopy Presentation LUT	**M**
SOP Common	**M**

Item #3: Add the following new section in Annex A.33

A.33.X XA/XRF Grayscale Softcopy Presentation State Information Object Definition

A.33.X.1 XA/XRF Grayscale Softcopy Presentation State IOD Description

The XA/XRF Grayscale Softcopy Presentation State Information Object Definition (IOD) specifies information that may be used to present angiographic projection images that are referenced from within the IOD.

It includes capabilities from the Grayscale Softcopy Presentation State IOD for specifying:

a. the output grayscale space in P-Values
b. grayscale contrast transformations including VOI LUT
c. selection of the area of the image to display and whether to rotate or flip it
d. image and display relative annotations, including graphics, text and overlays

For the presentation of angiographic projection images the following capabilities are provided:

a. shutter specifications on a frame-by-frame basis
b. mask subtraction including regional pixel shift
c. presentation of sets of frames

182 **A.33.X.2 XA/XRF Grayscale Softcopy Presentation State IOD Module Table**

Table A.33.X-1

184 **XA/XRF GRAYSCALE SOFTCOPY PRESENTATION STATE IOD MODULES**

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	Clinical Trial Subject	C.7.1.3	U
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
	Clinical Trial Study	C.7.2.3	U
Series	General Series	C.7.3.1	M
	Clinical Trial Series	C.7.3.2	U
	Presentation Series	C.11.9	M
Equipment	General Equipment	C.7.5.1	M
	Enhanced General Equipment	C.7.5.2	M
Presentation State	Presentation State Identification	C.11.10	M
	Presentation State Relationship	C.11.11	M
	Presentation State Shutter	C.11.12	M
	Bitmap Display Shutter	C.7.6.15	C - Required if a Display Shutter is to be applied to referenced image(s) and the XA/XRF Presentation State Shutter Module is not present
	Overlay Plane	C.9.2	C - Required if Overlay is to be applied to referenced image(s) or the Bitmap Display Shutter Module is present
	Overlay Activation	C.11.7	C- Required if referenced image contains overlay data that is to be displayed
	Displayed Area	C.10.4	M
	Graphic Annotation	C.10.5	C - Required if Graphic Annotations are to be applied to referenced image(s)
	Spatial Transformation	C.10.6	C - Required if rotation or flipping are to be applied to referenced image(s)
	Graphic Layer	C.10.7	C - Required if Graphic Annotations or Overlays or Curves are to be applied to referenced image(s)
	Softcopy VOI LUT	C.11.8	C - Required if a VOI LUT is to be applied to referenced image(s)

XA/XRF Presentation State Mask	C.11.X1	C - Required if the referenced image(s) are to be subtracted
XA/XRF Presentation State Shutter	C.11.X2	C - Required if a Display Shutter is to be applied to referenced image(s) and the Bitmap Display Shutter Module is not present
XA/XRF Presentation State Presentation	C.11.X3	C - Required if the referenced image(s) are to be displayed with a prescribed preference
Softcopy Presentation LUT	C.11.6	M
SOP Common	C.12.1	M

In the XA/XRF Grayscale Softcopy Presentation State IOD, the Presentation Series Module specializes some Attributes of the General Series Module, the XA/XRF Presentation State Mask Module specializes some Attributes of the Mask Module, and the XA/XRF Presentation State Shutter Module specializes some Attributes of the Bitmap Display Shutter and Display Shutter Modules.

Notes: 1. Subtraction between different images is not supported.

2. The Display Shutter may be used to darken image areas that surround important information and exclude extraneous bright areas that increase glare and ambient lighting impairing image interpretation. For example, unexposed areas in a XA image might be obscured using the Display Shutter, rather than permanently replacing image pixels in those areas.

3. This IOD does not support the storage of a multi-frame overlay in the IOD itself, but does support selective activation of multi-frame overlays within the referenced images via the Overlay Activation Module.

Item #4: Change and add the following sections of C.11

C.11 LOOK UP TABLES

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C.11.X1 XA/XRF Presentation State Mask Module

Table C.11-X1 specifies the Attributes that describe mask operations for a XA/XRF Multi-frame image.

Table C.11-X1
XA/XRF PRESENTATION STATE MASK MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Mask Subtraction Sequence	(0028,6100)	1	Defines a sequence that describes mask subtraction operations for Multi-frame Images. One or more items may be included in this sequence.

>Referenced Image Sequence	(0008,1140)	1C	A reference to a selected Image SOP Class/SOP Instance pair. Required if Presentation State Relationship Module references more than one SOP Instance. Only one Item is permitted.
>>Include 'SOP Instance Reference Macro' Table 10-11			
>Mask Operation	(0028,6101)	1	Defined Term identifying the type of mask operation to be performed. See C.7.6.10.1 for further explanation.
>Applicable Frame Range	(0028,6102)	1C	Each pair of numbers in this multi-valued attribute specifies a beginning and ending frame number inclusive of a range where this particular mask operation is valid. Discontinuous ranges are represented by multiple pairs of numbers. Frames in a Multi-frame Image are specified by sequentially increasing number values beginning with 1. If this Attribute is missing in this particular sequence item, then the mask operation is applicable throughout the entire Multi-frame Image, subject to certain limits as described in C.7.6.10.1.1. Each frame shall only be associated with a single Item of this sequence. Required if Mask Operation (0028,6101) equals REV_TID. May be present otherwise.
>Mask Frame Numbers	(0028,6110)	1C	Specifies the frame numbers of the pixel data used to generate this mask. Frames in a Multi-frame Image are specified by sequentially increasing number values beginning with 1. Required if the Mask Operation (0028,6101) is AVG_SUB.
>Contrast Frame Averaging	(0028,6112)	3	Specifies the number of contrast frames to average together before performing the mask operation. If the Attribute is missing, no averaging is performed.

>TID Offset	(0028,6120)	2C	If Mask Operation is TID, specifies the offset to be subtracted from the current frame number in order to locate the mask frame in TID mode. If Mask Operation is REV_TID, specifies the initial offset to be subtracted from the first contrast frame number. See section C.7.6.10.1.1. If zero length, TID Offset defaults to 1. Required if Mask Operation (0028,6101) is TID or REV_TID.
>Pixel Intensity Relationship LUT Sequence	(0028,9422)	1C	A sequence of Pixel Intensity Relationship LUTs that specifies a transformation to logarithmic space. One or more items shall be present in this sequence. Required if Pixel Intensity Relationship (0028,1040) is not LOG for frames included in this Item of the Mask Subtraction Sequence (0028,6100).
>>LUT Frame Range	(0028,9507)	1	Each pair of numbers in this multi-valued attribute specifies a beginning and ending frame number inclusive of a range where this LUT operation is specified. Discontinuous ranges are represented by multiple pairs of numbers. Frames in a Multi-frame Image are specified by sequentially increasing number values beginning with 1. Note: The specified frame numbers must be a part of the frames where this mask operation is valid.
>>LUT Descriptor	(0028,3002)	1	Specifies the format of the LUT Data in this Sequence. See C.11.1.1 and C.7.6.16.2.13.1 for further explanation.
>>LUT Data	(0028,3006)	1	LUT Data in this Sequence
>>LUT Function	(0028,9474)	1	The transformation function this LUT applies to the stored pixel values. Enumerate Values: TO_LOG
>Pixel Shift Sequence	(0028,9501)	1	Sequence containing the pixel shift values for the masks of the specified frame range(s) in the specified region(s). One or more items shall be present in this sequence.

>>Pixel Shift Frame Range	(0028,9506)	1	Each pair of numbers in this multi-valued attribute specify a beginning and ending contrast frame number inclusive of a range where this pixel shift is specified. Discontinuous ranges are represented by multiple pairs of numbers. Frames in a Multi-frame Image are specified by sequentially increasing number values beginning with 1. Overlapping frame ranges are not permitted. Note: The specified frame numbers must be a part of the frames where this mask operation is valid.
>>Region Pixel Shift Sequence	(0028,9502)	1	Sequence containing the pixel shifts for this frame(s). Only one sub region of this frame(s) shall be specified when the pixel shift is applicable for the full size or a single region of the frame(s). More than one sub region of this frame(s) may be specified when pixel shift is different in different regions. The order of Items in this sequence is significant, see C.11.X1.1.2. One or more items shall be present in this sequence.
>>>Mask Sub-pixel Shift	(0028,6114)	1	A pair of floating point numbers specifying the fractional vertical [adjacent row spacing] and horizontal [adjacent column spacing] pixel shift applied to the mask before subtracting it from the region of the frame numbers specified by Pixel Shift Frame Range (0028,9506) of this Pixel Shift Sequence (0028,9501) Item. The region is specified by the polygon defined by the Vertices of the Region (0028,9503) attribute. The pixels on the line of the polygon belong to the region. Note: If no pixel shift has to be applied a pair of zero attribute values (0.0\0.0) should be specified. See Section C.11.X1.1.1.

>>>Vertices of the Region	(0028,9503)	1C	Multiple Values where the first set of two values are: row of the origin vertex column of the origin vertex Two or more pairs of values follow and are the row and column coordinates of the other vertices of the polygon region. Each polygon region is implicitly closed from the last vertex to the origin vertex and all edges shall be non-intersecting except at the vertices. See C.11.X1.1.2. The upper left pixel of the image has the coordinate 1\1. Required if the pixel shift does not apply to the entire set of pixels of the frames.

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C.11.X1.1 XA/XRF Presentation State Mask Attributes

210 #### C.11.X1.1.1 Mask Sub-pixel Shift

A pair of floating point numbers specifying the fractional vertical [adjacent row spacing] and
212 horizontal [adjacent column spacing] pixel shift applied to the mask before subtracting it from the specified region of the contrast frame. The row offset results in a shift of the pixels along the
214 column axis. The column offset results in a shift of the pixels along the row axis. A positive row offset is a shift toward the pixels of the lower row of the pixel plane. A positive column offset is a
216 shift toward the pixels of the left hand side column of the pixel plane.

218 #### C.11.X1.1.2 Vertices of the Region

Each item of the Region Pixel Shift Sequence (0028,9502) specifies both a region of the contrast
220 frame and a mask pixel shift to be applied during the subtraction of that region.

When the Region Pixel Shift Sequence (0028,9502) contains more than one item, each region of
222 the contrast frame is subtracted by applying the corresponding pixel shift specified in that item.

When an item of the sequence does not contain the attribute Vertices of the Region (0028,9503),
224 the applicable region for that item is the whole contrast frame.

The union of all the regions defined in the Region Pixel Shift Sequence (0028,9502) does not
226 cover necessarily the whole contrast frame, in which case the pixels outside the union of all the regions shall be subtracted with no pixel shift.

228 If a set of pixels of the contrast frame is contained in more than one region, the applicable pixel shift is the one of the last item with the region that contains this set of pixels, as shown in Figure
230 C.11.X1-1.

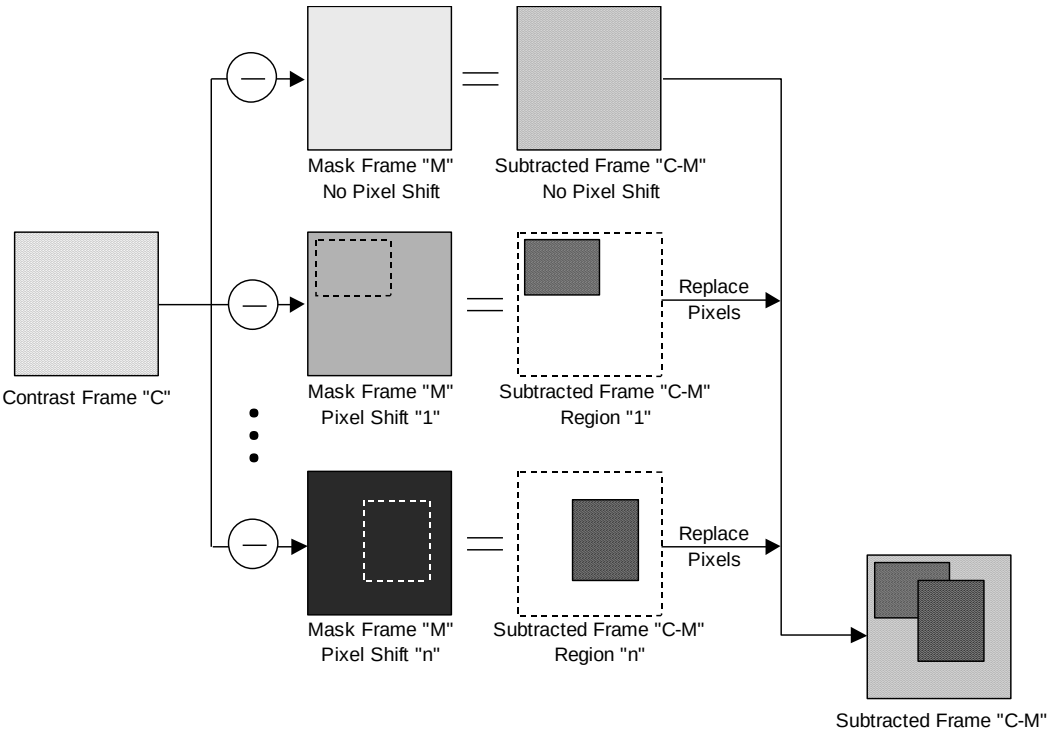

Figure C.11.X1-1
Applicable pixel shift in case of multiple pixel shift region**s**

Note: For example, the contrast frames 4 to 10 of a SOP Instance “A” are subtracted to the mask frame 1, the subtraction of the frames 4 to 7 being performed with three different values of mask pixel shift on overlapping rectangular regions: The (row,column) coordinates of the top-left and bottom-right vertices of the regions are 1: (1,1) to (30,60), 2: (10,40) to (50,120) and 3: (20,20) to (70,80). The mask pixel shift to be applied to the pixel (25,50) corresponds to the region 3 because this pixel is contained in the intersection of the three regions (See Figures C.11.X1-2 and C.11.X1-3).

Mask Subtraction Sequence		(0028,6100)	
	Item 1		
	>Referenced Image Sequence	(0008,1140)	
		Item 1	
		>>Referenced SOP Class UID	(0008,1150) = 1.2.840.10008.5.1.4.1.1.12.1.1
		>>Referenced SOP Instance UID	(0008,1155) = *UID "A"*
	>Mask Operation	(0028,6101)	= AVG_SUB
	>Applicable Frame range	(0028,6102)	= 4\10
	>Mask Frame Numbers	(0028,6110)	= 1
	>Pixel Shift Sequence	(0028,9510)	
		Item 1	
		>>Pixel Shift Frame range	(0029,9506) = 4\7
		>>Region Pixel Shift Sequence	(0029,9506)
			Item 1
			>>>Mask Sub-pixel Shift (0028,6114) = 1.2\3.4
			>>>Vertices of the Region (0028,9503) = 1\1\1\60\30\60\30\1
			Item 2
			>>>Mask Sub-pixel Shift (0028,6114) = -0.8\7.0
			>>>Vertices of the Region (0028,9503) = 10\40\10\120\50\120\50\40
			Item 3
			>>>Mask Sub-pixel Shift (0028,6114) = 0.0\-1.1
			>>>Vertices of the Region (0028,9503) = 20\20\20\80\70\80\70\20

Figure C.11.X1-2
Example of contents of Mask Subtraction Sequence

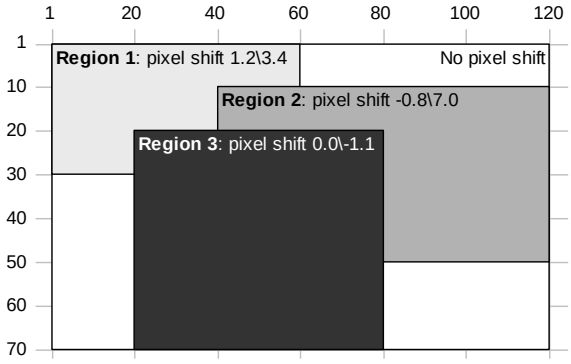

Figure C.11.X1-3
Example of three different pixel shift regions

C.11.X2 XA/XRF Presentation State Shutter Module

Table C.11-X2 specifies the Attributes that describe shutter operations for a XA/XRF Multi-frame image.

Table C.11-X2
XA/XRF PRESENTATION STATE SHUTTER MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Frame Display Shutter Sequence	(0028,9472)	1	Sequence of shutter specifications to be applied to groups of frames. One or more items may be present.
>Referenced Image Sequence	(0008,1140)	1C	Sequence of Items where each Item provides reference to a selected set of Image SOP Class/SOP Instance pairs that are defined in the Presentation State Relationship Module. One or more Items shall be present. Required if shutters in this Item do not apply to all the images and frames listed in the Presentation State Relationship Module.
>>Include 'Image SOP Instance Reference Macro' Table 10-3			
>Include 'Display Shutter Macro' Table C.7-17A.			

C.11.X3 XA/XRF Presentation State Presentation Module

Table C.11-X3 specifies the Attributes of a XA/XRF Presentation State Presentation Module.

Table C.11-X3
XA/XRF PRESENTATION STATE PRESENTATION MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Multi-frame Presentation Sequence	(0028,9505)	1	Describes for one or more SOP Instances the recommended playback and display preferences. One or more Items may be present.
>Referenced Image Sequence	(0008,1140)	1C	Sequence of Items where each Item provides reference to a selected set of Image SOP Class/SOP Instance pairs that are defined in the Presentation State Relationship Module. One or more Items may be present. Required if display sequences in this Item do not apply to all the images listed in the Presentation State Relationship Module.
>>Include 'SOP Instance Reference Macro' Table 10-11			
>Preferred Playback Sequencing	(0018,1244)	3	Describes the preferred playback sequencing for a multi-frame image. Enumerated Values: 0 = Looping (1,2...n,1,2,...n,1,2,....n,...) 1 = Sweeping (1,2,...n,n -1,...2,1,2,...n,...)

>Frame Display Sequence	(0008,9458)	3	Sequence that specifies the display frame rate of a selected set of frames. The Items are ordered in increasing frame number. The range of the frames may not overlap and the ranges shall be adjacent. One or more items may be included.
>>Start Trim	(0008,2142)	1	The Frame Number of the first frame of the set of frames to be displayed in this Item.
>>Stop Trim	(0008,2143)	1	The Frame Number of the last frame of the set of frames to be displayed in this Item.
>>Skip Frame Range Flag	(0008,9460)	1	A flag indicating that the range of frames in this item may be skipped. Defined Terms: DISPLAY SKIP
>>Recommended Display Frame Rate in Float	(0008,9459)	1	Recommended rate at which the frames of this Item should be displayed in frames/second.
>>Recommended Viewing Mode	(0028,1090)	2	Specifies the recommended viewing protocol(s). Defined terms: SUB = subtraction with mask images NAT = native viewing of image as stored Note: If an implementation does not recognize the defined term for Recommended Viewing Mode (0028,1090), reverting to native display mode is recommended.
>>Display Filter Percentage	(0028,9411)	2	Edge enhancement filter percentage that is recommended by the pixel data creator as filter presetting for display purposes. The value of 100 corresponds to the maximum filter strength that can be applied by a specific application displaying the image.
>Mask Visibility Percentage	(0028,9478)	1C	The percentage of visibility of the mask frame during a subtracted display. A value of 0 corresponds to subtracted display, a value of 100 corresponds to un-subtracted display (native). See C.8.19.7.1.. Note: The value of 100 is equivalent to Recommended Viewing Mode (0028,1090) having a value of NAT. Required if Recommended Viewing Mode (0028,1090) equals SUB.

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Changes to NEMA Standards Publication PS 3.4-2004

278 ## Digital Imaging and Communications in Medicine (DICOM)

Part 4: Service Class Specifications

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Item #6: Add the following to Table B.5-1

B.5 STANDARD SOP CLASSES

Table B.5-1
STANDARD SOP CLASSES

SOP Class Name	SOP Class UID	IOD Specification (defined in PS 3.3)
XA/XRF Grayscale Softcopy Presentation State Storage	1.2.840.10008.5.1.4.1.1.11.5	XA/XRF Grayscale Softcopy Presentation State

Item #8: Add the following to Table I.4-1

I.4 MEDIA STORAGE STANDARD SOP CLASSES

Table I.4-1
Media Storage Standard SOP Classes

SOP Class Name	SOP Class UID	IOD Specification
XA/XRF Grayscale Softcopy Presentation State Storage	1.2.840.10008.5.1.4.1.1.11.5	IOD defined in PS 3.3

Item #9: Add section to Annex N.2

N.2.X Angiography Grayscale Transformations

The XA/XRF Grayscale Softcopy Presentation State Storage SOP Classe supports a sequence of transformations that completely define the conversion of a stored image into a displayed image.

The sequence of transformations from stored pixel values into P-Values is explicitly defined in a conceptual model. The actual sequence implemented may differ but must result in the same appearance. Figure N.2-X1 describes this sequence of transformations.

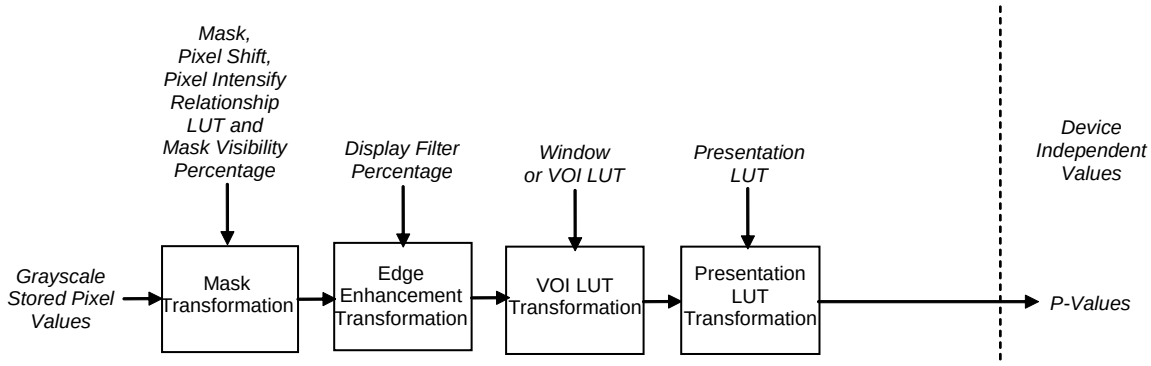

Figure N.2-X1
XA/XRF Grayscale Image Transformation Model

N.2.X.1 Mask

The Mask transformation consists of mask subtraction operations as specified by the attributes of the XA/XRF Presentation State Mask module and the attribute Mask Visibility Percentage of the XA/XRF Presentation State Presentation module.

The mask transformation may be applied in the case of multi-frame images for which other frames at a fixed frame position or time interval relative to the current frame may be subtracted from the current frame. Multiple mask frames may be averaged, and sub-pixel shifted before subtraction. Sub-pixel shift may be specified on a frame-by-frame base. Different pixel-shifts may be applied to more than one region of a contrast frame.

In the case of X-Ray images, the subtraction is specified to take place in a space logarithmic to X-Ray intensity. If the stored pixel values are not in a logarithmic space then a Pixel Intensity Relationship LUT shall be present in the XA/XRF Presentation Mask Module specifying a transformation into such a logarithmic space, otherwise it shall not be present. If a Modality LUT or Pixel Intensity Relationship LUT is present in the referenced image(s) it shall be ignored. The Pixel Intensity Relationship LUT can be specified on a frame-by frame base which can be different for mask and contrast frames.

Notes: 1. For images of the X-Ray Angiographic Image Storage SOP Class or X-Ray RF Image Storage SOP Class the XA/XRF Grayscale Softcopy Presentation State allows a Pixel Intensity Relationship LUT to be specified on a frame-by-frame base. This is an enhancement of the image Modality LUT which is only applicable for all frames of an image.

2. In the case of an XA or XRF image, if the Pixel Intensity Relationship (0028,1040) in the image is LOG, then even though a Modality LUT would be present in the image (to map pixel values back to linear X-Ray intensity), no Pixel Intensity Relationship LUT would be present in the presentation state for any frame since log values are required for subtraction. See PS 3.3 C.8.7.1.1.2.

In the case of Enhanced XA or XRF image, if the Pixel Intensity Relationship (0028,1040) in the frame is LOG, then even though a Pixel Intensity Relationship LUT would be present in the frame (to map pixel values back to linear X-Ray intensity, LUT Function (0028,9474) equals TO_LINEAR), no Pixel Intensity Relationship LUT would be present in the presentation state for that frame since log values are required for subtraction. See PS 3.3 C.7.6.16.2.13.

3 In the case of an XA or XRF image if the Pixel Intensity Relationship (0028,1040) in the image is LIN, then no Modality LUT would be present in the image, but a Pixel Intensity Relationship LUT would need to be present (to map pixel values to log values, LUT Function (0028,9474) equals TO_LOG) in the presentation state for all the frames since log values are required for subtraction.

In the case of an Enhanced XA or XRF image, if the Pixel Intensity Relationship (0028,1040) in the frame is LIN, then no Pixel Intensity Relationship LUT for the purpose to map pixel values back to linear X-Ray intensity (LUT Function (0028,9474) equals TO_LINEAR) would

be present in the image, but a Pixel Intensity Relationship LUT would need to be present (to map pixel values to log values) in the presentation state for that frame since log values are required for subtraction.

4. In the case of an XA or XRF image, if the Pixel Intensity Relationship (0028,1040) in the image is DISP, then even though a Modality LUT may or may not be present in the image (to map pixel values back to linear to X-Ray intensity), a different Pixel Intensity Relationship LUT would be present in the presentation state if the creator of the presentation state could create a transformation from DISP pixel values to a logarithmic space for subtraction, or the Pixel Intensity Relationship LUT in the presentation state would be an identity transformation if the DISP pixel values were known to already be log values required for subtraction.

In the case of an Enhanced XA or XRF image, if the Pixel Intensity Relationship (0028,1040) in the image is OTHER, then even though a Pixel Intensity Relationship LUT may or may not be present for that frame (to map pixel values back to linear to X-Ray intensity), a different Pixel Intensity Relationship LUT would be present in the presentation state for that frame if the creator of the presentation state could create a transformation from OTHER pixel values to a logarithmic space for subtraction, or the Pixel Intensity Relationship LUT in the presentation state would be an identity transformation if the OTHER pixel values were known to already be log values required for subtraction.

5. Notes 2, 3 and 4 are summarized in Table N.2.X.1-1

Table N.2.X.1-1
Summary of providing a LUT function for subtraction

Pixel Intensity Relationship (0028,1040) attribute of the referenced SOP Instance	**The contents of Pixel Intensity Relationship LUT Sequence (0028,9422) in XA/XRF Presentation State Mask Module**
LIN	TO_LOG LUT provided
LOG	absent
DISP or OTHER	TO_LOG LUT provided, may be an identity

N.2.X.2 Edge Enhancement

The Edge Enhancement transformation consists of filter operations to enhance the display of the pixel data as specified by the attribute Display Filter Percentage of the XA/XRF Presentation State Presentation module.

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Changes to NEMA Standards Publication PS 3.6-2004

378 # Digital Imaging and Communications in Medicine (DICOM)

Part 6: Data Dictionary

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Item #9: Add or the following Data Elements to Part 6 Section 6:

6 Registry of DICOM data elements

Tag	Name	VR	VM
(0028,9501)	Pixel Shift Sequence	SQ	1
(0028,9502)	Region Pixel Shift Sequence	SQ	1
(0028,9503)	Vertices of the Region	SS	2-2n
(0028,9505)	Multi-frame Presentation Sequence	SQ	1
(0028,9506)	Pixel Shift Frame Range	US	2-2n
(0028,9507)	LUT Frame Range	US	2-2n

Item #10: Add the following UID to Part 6 Annex A:

Annex A Registry of DICOM unique identifiers (UID) (Normative)

Table A-1
UID VALUES

UID Value	UID NAME	UID TYPE	Part
1.2.840.10008.5.1.4.1.1.11.5	XA/XRF Grayscale Softcopy Presentation State Storage	SOP Class	PS 3.4