Digital Imaging and Communications in Medicine (DICOM)

Volume Rendering Volumetric Presentation States

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Developed pursuant to Work Item 2008-04-C

VERSION: Final Text - 21 April 2017

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Scope and Field of Application

DICOM has added SOP Classes for representing Planar MPR Volumetric Presentation States (see DICOM PS3.3 Section A.80.1). This supplement extends the family of Volumetric Presentation States by adding three additional SOP Classes to represent Volume Rendering Volumetric Presentation States:

- one allowing a single input volume and excluding segmentation cropping
- one allowing a single input volume with multiple input segmentations each with a distinct classification map
- one allowing multiple input volumes, segmentations, and classification maps

Note that the technique of Surface Rendering, such as the rendering of Surface Segmentations or surfaces from the Optical Surface Scanner SOP Class, is not in the scope of this Supplement.

Volume Rendering is a data visualization method in which voxels (volume sample points) are assigned a color and opacity (alpha), and a 2D view is created by accumulating a set of non-transparent samples along a ray through the volume behind each pixel of the view. Ray samples are calculated by interpolating the voxel values in the neighborhood of each sample.

Volume Rendering generally consists of a number of steps, many of which are parametrically specified in the Volume Rendering SOP Classes. The processing steps are:

- Segmentation, or separating the volume data into groups that will share a particular color palette. Segmentation objects are specified as cropping inputs to the Volumetric Presentation State.
- Gradient Computation, or finding edges or boundaries between different types of tissue in the volumetric data. The gradient computation method used is an implementation decision outside the scope of the Volumetric Presentation State.
- Resampling of the volumetric data to create new samples along the imaginary ray behind each pixel in the output two-dimensional view, generally using some interpolation of the values of voxels in the neighborhood of the new sample. The interpolation method used is an implementation decision outside the scope of the Volumetric Presentation State.
- Classification of samples to assign a color and opacity to each sample.
- Shading or the application of a lighting model to samples indicating the effect of ambient, diffuse, and specular light on the sample.
- Compositing or the accumulation of samples on each ray into the final value of the pixel corresponding to that ray. The specific algorithms used are outside the scope of the Volumetric Presentation State.

Refer to Section A.80.2.1 for a list of the parameters that are specified in the Volumetric Presentation State.

The result of applying a Volumetric Presentation State is not expected to be exactly reproducible on different systems. It is difficult to describe the display and rendering algorithms in enough detail in an interoperable manner, such that a presentation produced at a later time would be indistinguishable from that of the original presentation. Volumetric Presentation States use established DICOM concepts of grayscale and color matching (GSDF and ICC color profiles) and provides a generic description of the different types of display algorithms possible. Variations in algorithm implementations within display devices are inevitable and an exact match of volume presentation on multiple devices cannot be guaranteed. Reasonable consistency is provided by specification of inputs, geometric descriptions of spatial views, type of processing to be used, color mapping and blending, input fusion, and many generic rendering parameters, producing what is expected to be a clinically acceptable result.

The Volume Rendering Volumetric Presentation State also provides for alpha compositing (blending) of multiple volumes and/or segmented volumes into a single volume dataset in preparation for the Volume Rendering operation.

Changes to NEMA Standards Publication PS3.2-2016e

Digital Imaging and Communications in Medicine (DICOM)

Part 2: Conformance

Item #1: Add SOP Classes to PS3.2 Table A.1-2

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

UID Value	UID NAME	Category
…		
1.2.840.10008.5.1.4.1.1.11.9	**Volume Rendering Volumetric Presentation State Storage SOP Class**	**Transfer**
1.2.840.10008.5.1.4.1.1.11.10	**Segmented Volume Rendering Volumetric Presentation State Storage SOP Class**	**Transfer**
1.2.840.10008.5.1.4.1.1.11.11	**Multiple Volume Rendering Volumetric Presentation State Storage SOP Class**	**Transfer**
…		

Changes to NEMA Standards Publication PS3.3-2016e

Digital Imaging and Communications in Medicine (DICOM)

Part 3: Information Object Definitions

Item #2: Add references to PS3.3 Section 2

2.6 Other References

[Phong 1975] Communications of the ACM. B. T. Phong 1975, 18 6 311-317 "Illumination for computer generated pictures"

[Porter-Duff 1984] SIGGRAPH '84 Proceedings of the 11th annual conference on Computer graphics and interactive techniques. T. Porter and T Duff 1984, 253-259 "Compositing Digital Images"

Item #3: Changes/additions to PS3.3 Table A.1-6

IODs **Modules**	Planar MPR Vol Pres State	**Volume Rendering** **Vol Pres State**
Patient	M	**M**
Clinical Trial Subject	U	**U**
General Study	M	**M**
Patient Study	U	**U**
Clinical Trial Study	U	**U**
General Series	M	**M**
Clinical Trial Series	U	**U**
Presentation Series	M	**M**
Frame Of Reference	M	**M**
General Equipment	M	**M**
Enhanced General Equipment	M	**M**
Graphic Annotation	U	**U**
Graphic Layer	C	**C**
Volumetric Presentation State Identification	M	**M**
Volumetric Presentation State Relationship	M	**M**
Volume Cropping	~~**U**~~ **C**	**C**
Presentation View Description	M	**M**
Multi-Planar Reconstruction Geometry	M	
Volume Render Geometry		**M**
Render Shading		**U**
MPR Volumetric Presentation State Display	M	
Render Display		**M**

Volumetric Graphic Annotation	U	**U**
Graphic Group	U	**U**
Presentation Animation	U	**U**
Common Instance Reference	M	**M**
SOP Common	M	**M**

Item #4: Add sections to PS3.3 Annex A.80

A.80.2 VOLUME RENDERING VOLUMETRIC PRESENTATION STATE INFORMATION OBJECT DEFINITION

A.80.2.1 Volume Rendering Volumetric Presentation State Description

The Volume Rendering Volumetric Presentation State Information Object Definition (IOD) specifies information that defines a Volume Rendering presentation from volume datasets that are referenced from within the IOD.

It includes capabilities for specifying:

a. spatial registration of the input datasets
b. cropping of the volume datasets by a bounding box, oblique planes and segmentation objects
c. the generation geometry of volume rendered reconstruction
d. shading models
e. scalar to RGB conversions
f. compositing of multiple volume streams and one volume stream with segmentations
g. clinical description of the specified view
h. volume-relative and display-relative annotations, including graphics, text and overlays plus optional references to structured content providing clinical context to annotations.
i. membership in a collection of related Volumetric Presentation States intended to be processed or displayed together
j. the position within a set of sequentially related Volumetric Presentation States
k. animation of the view
l. reference to an image depicting the view described by the Volumetric Presentation State

The Volume Rendering Volumetric Presentation State IOD is used in three SOP Classes as defined in PS3.4:

- one SOP Class allowing a single input volume and excluding segmentation cropping
- one SOP Class allowing a single input volume with multiple input segmentations each with a distinct classification map
- one SOP Class allowing multiple input volumes, segmentations, and classification maps

A.80.2.2 Volume Rendering Volumetric Presentation State IOD Entity-Relationship Model

This IOD uses the E-R Model in Section A.1.2, with only the Presentation State IE below the Series IE.

A.80.2.3 Volume Rendering Volumetric Presentation State IOD Module Table

220 Table A.80.x3-1 specifies the Modules of the Volume Rendering Volumetric Presentation State IOD.

Table A.80.x3-1
VOLUME RENDERING VOLUMETRIC 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.11.10	M
Frame of Reference	Frame of Reference	C.7.4.1	M
Equipment	General Equipment	C.7.5.1	M
	Enhanced General Equipment	C.7.5.2	M
Presentation State	Volumetric Presentation State Identification	C.11.22	M
	Volumetric Presentation State Relationship	C.11.23	M
	Volume Cropping	C.11.24	C Required if Global Crop (0070,120B) or any value of Crop (0070,1204) is YES.
	Presentation View Description	C.11.25	M
	Volume Render Geometry	C.11.30	M
	Render Shading	C.11.31	U
	Render Display	C.11.32	M
	Volumetric Graphic Annotation	C.11.28	U
	Graphic Annotation	C.10.5	U
	Graphic Layer	C.10.7	C Required if Graphic Layer (0070,0002) is present in the Volumetric Graphic Annotation Module or Graphic Annotation Module
	Graphic Group	C.10.11	U
	Presentation Animation	C.11.29	U

	SOP Common	C.12.1	M
	Common Instance Reference	C.12.2	M

A.80.2.4 Volume Rendering Volumetric Presentation State IOD Content Constraints

A.80.2.4.1 Presentation Input Restrictions

Presentation Input Type (0070,1202) shall have a value of VOLUME.

See PS3.4 Section B.5.1.24 for SOP Class-specific Presentation Input Restrictions.

A.80.2.4.2 Graphic Annotation Module

The values of the following attributes, if present, shall be DISPLAY:

- Bounding Box Annotation Units (0070,0003)
- Anchor Point Annotation Units (0070,0004)
- Graphic Annotation Units (0070,0005)
- Compound Graphics Units (0070,0282)

Note: The specified annotation is associated with the specified View and not with the input data, and may have clinical relevance only to the specified View. Therefore, if an application alters the View from that defined by the Presentation State, annotation may no longer be clinically correct.

A.80.2.4.3 Render Shading Module

If the Render Shading Module is omitted for a rendered view, an unshaded volume rendering shall be performed.

A.80.2.4.4 Volumetric Presentation State Reference Coordinate System

All SOP Instances referenced in the Volumetric Presentation State Relationship Module shall be registered to the Volumetric Presentation State Reference Coordinate System. See C.11.23.3.

Item #5: Changes to PS3.3 Annex A.80

A.80.1.3 Planar MPR Volumetric Presentation State IOD Module Table

Table A.80.1-1. Planar MPR Volumetric 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.11.10	M

Frame of Reference	Frame of Reference	C.7.4.1	M
Equipment	General Equipment	C.7.5.1	M
	Enhanced General Equipment	C.7.5.2	M
Presentation State	Volumetric Presentation State Identification	C.11.22	M
	Volumetric Presentation State Relationship	C.11.23	M
	Volume Cropping	C.11.24	~~U~~ **C** **Required if Global Crop (0070,120B) or any value of Crop (0070,1204) is YES.**
	Presentation View Description	C.11.25	M
	Multi-Planar Reconstruction Geometry	C.11.26	M
	MPR Volumetric Presentation State Display	C.11.27	M
	Volumetric Graphic Annotation	C.11.28	U
	Graphic Annotation	C.10.5	U
	Graphic Layer	C.10.7	C Required if Graphic Layer (0070,0002) is present in ~~**Volumetric Presentation State Relationship Module,**~~ **the Volumetric Graphic Annotation Module or Graphic Annotation Module**
	Graphic Group	C.10.11	U
	Presentation Animation	C.11.29	U
	SOP Common	C.12.1	M
	Common Instance Reference	C.12.2	M

A.80.1.4.5 Volumetric Presentation State Reference Coordinate System

All SOP Instances referenced in the Volumetric Presentation State Relationship Module shall be ~~**implicitly or explicitly**~~ registered to the Volumetric Presentation State Reference Coordinate System. See Section C.11.23.3.

Item #6: Add to PS3.3 Annex C

C.11.30 Volume Render Geometry Module

Table C.11.30-1 contains Attributes that describe the geometry of the volume rendered view.

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Table C.11.30-1
VOLUME RENDER GEOMETRY MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Render Projection	(0070,1602)	1	Projection style. Enumerated Values: ORTHOGRAPHIC PERSPECTIVE
Viewpoint Position	(0070,1603)	1	Position of the viewpoint in volume space. A point (x,y,z) in the Volumetric Presentation State Reference Coordinate System.
Viewpoint LookAt Point	(0070,1604)	1	Point the viewpoint is looking at. A point (x,y,z) in the Volumetric Presentation State Reference Coordinate System.
Viewpoint Up Direction	(0070,1605)	1	Vertical orientation of the view. A vector (x,y,z) in the Volumetric Presentation State Reference Coordinate System.
Render Field of View	(0070,1606)	1	The field of view specified as a 6-tuple of values (X_{left}, X_{right}, Y_{top}, Y_{bottom}, $Distance_{near}$, $Distance_{far}$) in the Viewpoint Coordinate System, in mm. See C.11.30.1.
Rendering Method	(0070,120D)	1	The rendering method used during the ray casting compositing operation. Enumerated values: MAXIMUM_IP: A method that projects the interpolated sample with maximum intensity that falls in the path of each ray traced from the viewpoint to the plane of projection. MINIMUM_IP: A method that projects the interpolated sample with minimum intensity that falls in the path of each ray traced from the viewpoint to the plane of projection. VOLUME_RENDERED: A method where each XY pixel of the rendered view is determined by accumulating the set of non-transparent voxel samples along a ray.
Sampling Step Size	(0070,1607)	3	Spacing in mm between samples along each ray in the original volume rendering operation. See C.11.30.2.

C.11.30.1 Render Field of View

The Render Field of View (0070,1606) defines the region of the volume data that is displayed.

The viewpoint is positioned and oriented within the Volumetric Presentation State Reference Coordinate System (VPS-RCS) by Viewpoint Position (0070,1603), Viewpoint LookAt Point (0070,1604), and Viewpoint Up Direction (0070,1605). This position and orientation establish a Viewpoint Coordinate System (VCS), which is a right-hand coordinate system in which the viewpoint is positioned at (0,0,0) and is looking at a point at (0,0,-z) and the up direction is along the +y axis.

Render Field of View (0070,1606) is specified by the following coordinate values in the Viewpoint Coordinate System:

- $Distance_{near}$, $Distance_{far}$ specify the distances from Viewpoint Position (0070,1603) to the near and far depth clipping planes. Both distances shall be positive, and $Distance_{near}$ shall be less than $Distance_{far}$.
- X_{left}, X_{right} specify the coordinates of the left and right vertical clipping planes at $Distance_{far}$. X_{left} shall be less than $X_{right.}$
- Y_{top}, Y_{bottom} specify the coordinates for the top and bottom horizontal clipping planes at $Distance_{far}$. X_{left} shall be less than $X_{right.}$

Note: Positive values of $Distance_{near}$ and $Distance_{far}$ place the near and far rectangles of the field of view on the negative Z axis at Z values of -$Distance_{near}$ and -$Distance_{far}$, respectively.

In the case of a Render Projection (0070,1602) value of ORTHOGRAPHIC, Render Field of View (0070,1606) defines a rectangular cuboid with dimensions (X_{right} minus X_{left}) by (Y_{top} minus Y_{bottom}) by ($Distance_{far}$ minus $Distance_{near}$), in mm, as shown in Figure C.11.30-1:

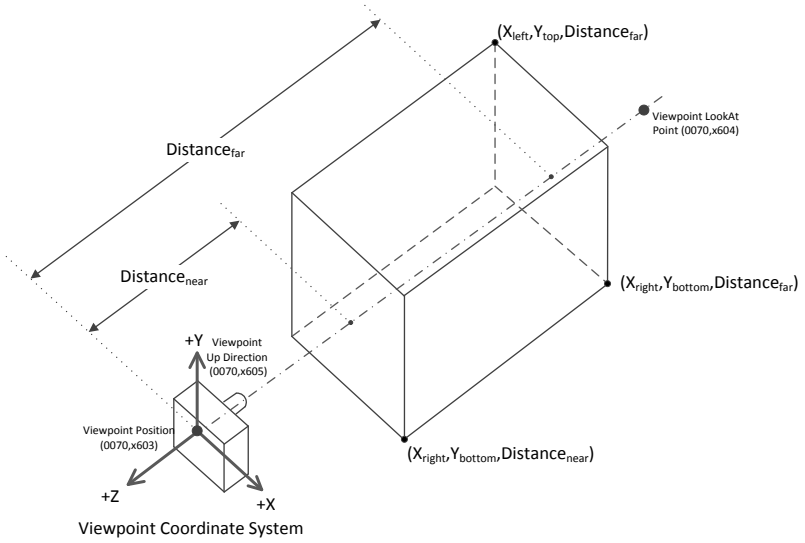

Figure C.11.30-1: ORTHOGRAPHIC Field of View Geometry

In the case of a Render Projection (0070,1602) value of PERSPECTIVE, Render Field of View (0070,1606) defines a frustum in which the far rectangle is larger than the near rectangle. The extent of the far rectangle is established by the points (X_{left}, Y_{top}) and (X_{right}, Y_{bottom}) at $Distance_{far}$. The extent of the near rectangle is established by the four points where rays originating at the viewpoint position to the corners of the far rectangle intersect the plane that is located at $Distance_{near}$ from the viewpoint, as shown in Figure C.11.30-2.

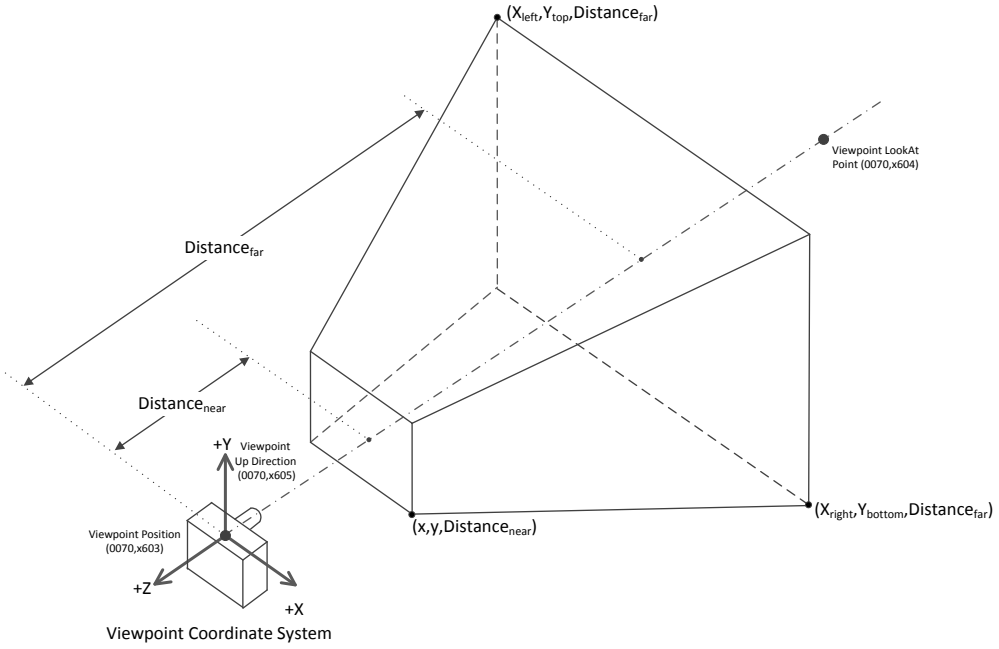

Figure C.11.30-2: PERSPECTIVE Field of View Geometry

C.11.30.2 Sampling Step Size

Sampling Step Size (0070,1607) specifies the spacing in mm between samples along each ray that was used in the original view by the creator of the Presentation State. A display application may choose to use a different step size, but this will usually require an adjustment to the Alpha LUTs found in the Presentation State Classification Component Sequence (0070,1801) to compensate the change in opacity accumulation caused by the different step size.

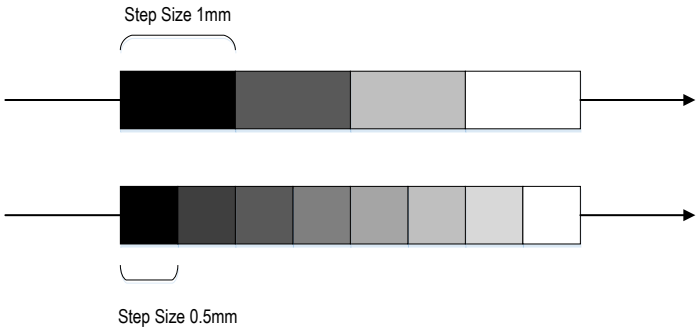

Figure C.11.30-3: Sampling Step Size

C.11.31 Render Shading Module

Shading enhances the visual perception of a volume by adding reflection characteristics. Table C.11.31-1 contains Attributes that describe the shading used in a rendered view.

Note: This module assumes a Phong shading model. An implementation may use any appropriate shading model, translating these parameters into a similar meaning in the chosen shading model. The generation mechanism for the surface normals that are required for the Phong shading model is not

specified by DICOM.

Table C.11.31-1
RENDER SHADING MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Shading Style	(0070,1701)	1	Enumerated Values: SINGLESIDED DOUBLESIDED See C.11.31.1
Ambient Reflection Intensity	(0070,1702)	1	Intensity of the ambient reflection in the relative range 0.0 to 1.0, inclusive.
Light Direction	(0070,1703)	1C	The direction light is traveling from a single white light source at infinity. Represented as a unit vector encoded as three coordinates (x,y,z) in the VPS-RCS. Required if Diffuse Reflection Intensity (0070,1704) or Specular Reflection Intensity (0070,1705) is present.
Diffuse Reflection Intensity	(0070,1704)	3	Intensity of the diffuse reflection in the relative range 0.0 to 1.0, inclusive. If absent, a value of zero is assumed.
Specular Reflection Intensity	(0070,1705)	3	Intensity of the specular reflection in the relative range 0.0 to 1.0, inclusive. If absent, a value of zero is assumed.
Shininess	(0070,1706)	3	Specifies the roughness of the rendered surfaces, in the relative range 0.0 to 1.0, inclusive. A value of 0.0 represents a rough surface and a value of 1.0 represents the smoothest surface which can be generated by the implementation. Note: In theory, the range of shininess is from 0 to infinity. However, in practice each implementation has a finite upper limit for shininess. The implementation is expected to multiply this value by its upper limit value and use the result in its shading algorithm for shininess. If absent, the shininess is an implementation decision.

C.11.31.1 Shading Style

The Shading Style (0070,1701) determines if the shading calculations are performed for all voxels, based on the facing of the surface normal which has been generated for that voxel:

- SINGLESIDED: only “front-facing” voxels are shaded.
- DOUBLESIDED: “front-facing” and “back-facing” voxels are shaded.

Note: “Front-facing” voxels are those with a negative dot product between the surface normal which has been generated for that voxel and the vector between the Viewpoint Position (0070,1603) and the ViewPoint LookAt Point (0070,1604). “Back-facing” voxels are those with a positive dot product.

C.11.32 Render Display Module

320 Table C.11.32-1 specifies the attributes that define the transformations of the processed Volumetric Presentation State inputs into a single VPS display space, as described in the Volumetric Presentation State pipelines in PS3.4 Section X.2.2.

Table C.11.32-1
RENDER DISPLAY MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Pixel Presentation	(0008,9205)	1	Grayscale or color space of the Presentation State output. Enumerated Values: TRUE_COLOR Output consists of PCS-Values
Volume Stream Sequence	(0070,1A08)	1	Volumetric source input streams combined through Volume Blending. One or more items shall be included in this sequence.
>Volumetric Presentation Input Set UID	(0070,1209)	1	Unique identifier of the input set processed in this volume stream. Corresponds to the item in Volume Presentation Input Set Sequence (0070,120A) with this UID. See C.11.23.4.
>Presentation State Classification Component Sequence	(0070,1801)	1	Classification components in which the order of items is significant. Each classification component converts one or two processed inputs into a single RGB output. One or more items shall be included in this sequence. See C.11.27.2.
>>RGBA Transfer Function Description	(0070,1A09)	3	Label describing the clinical significance of the RGBA transfer function.
>>Component Type	(0070,1802)	1	Type of component. Enumerated values: ONE_TO_RGBA TWO_TO_RGBA See C.11.27.2.
>>Component Input Sequence	(0070,1803)	1	Specification of the input or inputs to this component. One item shall be present in this sequence if Component Type (0070,1802) has a value of ONE_TO_RGBA. Two items shall be present in this sequence if Component Type (0070,1802) has a value of TWO_TO_RGBA.

>>> Volumetric Presentation Input Index	(0070,1804)	1	Volumetric Presentation Input Number (0070,1207) for this input in the Volumetric Presentation State Input Sequence (0070,1201).
>>>Bits Mapped to Color Lookup Table	(0028,1403)	3	The number of most significant bits of each value of Pixel Data (7FE0,0010) from this frame contributing to the Palette Color Lookup Table input. If absent, Bits Stored (0028,0101) bits of each value of Pixel Data (7FE0,0010) from this frame contributes to the Palette Color Lookup Table input. See C.7.6.23.3.
>>RGB LUT Transfer Function	(0028,140F)	1	Specifies the mapping that takes place between the input value and RGB output. Enumerated values: EQUAL_RGB Output is R=G=B = input value TABLE Output is RGB LUT values See C.11.x8.1.
>>Alpha LUT Transfer Function	(0028,1410)	1	Specifies the transformation that is used to create the Alpha input to a compositor component (if present) and the opacity value for use in the Volume Rendering compositor. Enumerated values: NONE Output = 1 (opaque) for all input values IDENTITY Output = input value TABLE Output = output of the Alpha LUT
>>Red Palette Color Lookup Table Descriptor	(0028,1101)	1C	Specifies the format of the Red Palette Color Lookup Table Data (0028,1201). The second value (first stored pixel value mapped) shall be zero. See C.7.6.3.1.5. Required if RGB LUT Transfer Function (0028,140F) has a value of TABLE.
>>Green Palette Color Lookup Table Descriptor	(0028,1102)	1C	Specifies the format of the Green Palette Color Lookup Table Data (0028,1202). The second value (first stored pixel value mapped) shall be zero. See C.7.6.3.1.5. Required if RGB LUT Transfer Function (0028,140F) has a value of TABLE.

>>Blue Palette Color Lookup Table Descriptor	(0028,1103)	1C	Specifies the format of the Blue Palette Color Lookup Table Data (0028,1203). The second value (first stored pixel value mapped) shall be zero. See C.7.6.3.1.5. Required if RGB LUT Transfer Function (0028,140F) has a value of TABLE.
>>Alpha Palette Color Lookup Table Descriptor	(0028,1104)	1C	Specifies the format of the Alpha Palette Color Lookup Table Data. The second value (first stored pixel value mapped) shall be zero. See C.7.6.3.1.5. Required if Alpha LUT Transfer Function (0028,1410) has a value of TABLE.
>>Palette Color Lookup Table UID	(0028,1199)	3	Palette Color Lookup Table UID. See C.7.9.1. Note: Including the Palette Color Lookup Table UID in Presentation States that use the same palette is helpful to the display application that is rendering several related presentations together.
>>Red Palette Color Lookup Table Data	(0028,1201)	1C	Red Palette Color Lookup Table Data. See C.7.6.3.1.5. Required if RGB LUT Transfer Function (0028,140F) has a value of TABLE and Segmented Red Palette Color Lookup Table Data (0028,1221) is not present.
>>Green Palette Color Lookup Table Data	(0028,1202)	1C	Green Palette Color Lookup Table Data. See C.7.6.3.1.5. Required if Red Palette Color Lookup Table Data (0028,1201) is present.
>>Blue Palette Color Lookup Table Data	(0028,1203)	1C	Blue Palette Color Lookup Table Data. See C.7.6.3.1.5. Required if Red Palette Color Lookup Table Data (0028,1201) is present.
>>Alpha Palette Color Lookup Table Data	(0028,1204)	1C	Alpha Palette Color Lookup Table Data. See C.7.6.3.1.5. Required if Alpha LUT Transfer Function (0028,1410) has a value of TABLE and Segmented Alpha Palette Color Lookup Table Data (0028,1224) is not present.

>>Segmented Red Palette Color Lookup Table Data	(0028,1221)	1C	Segmented Red Palette Color Lookup Table Data. See C.11.27.5. Required if RGB LUT Transfer Function (0028,140F) has a value of TABLE and Red Palette Color Lookup Table Data (0028,1201) is not present.
>>Segmented Green Palette Color Lookup Table Data	(0028,1222)	1C	Segmented Green Palette Color Lookup Table Data. See C.11.27.5 Required if Segmented Red Palette Color Lookup Table Data (0028,1221) is present.
>>Segmented Blue Palette Color Lookup Table Data	(0028,1223)	1C	Segmented Blue Palette Color Lookup Table Data. See C.11.27.5 Required if Segmented Red Palette Color Lookup Table Data (0028,1221) is present.
>>Segmented Alpha Palette Color Lookup Table Data	(0028,1224)	1C	Segmented Alpha Palette Color Lookup Table Data. See C.11.27.5 Required if Alpha LUT Transfer Function (0028,1410) has a value of TABLE and Alpha Palette Color Lookup Table Data (0028,1204) is not present.
Presentation State Compositor Component Sequence	(0070,1805)	2	RGBA Compositor components. Each RGBA Compositor component combines pairs of RGBA values to produce a single RGBA value. The order of items is significant. If there are more than one compositor component, the components are chained such that the output of one compositor component is an input to the next compositor component. The number of items in this sequence shall be the one less than the number of items in Volume Stream Sequence (0070,1A08). See C.11.27.3.

>Weighting Transfer Function Sequence	(0070,1806)	1	Transfer functions used to derive the weighting factors for each of the two RGB inputs from both input Alphas. Each function is represented by the formula $f(Alpha_1, Alpha_2) = WeightingFactor$ The function is specified in the form of a table. Two items shall be included in this sequence. The order is significant. The first item specifies the weighting factor for RGB1 and the second item specifies the weighting factor for RGB2. See C.11.27.4.
>>LUT Descriptor	(0028,3002)	1	Specifies the format of the LUT Data (0028,3006) in this Sequence. The first value (number of entries in the LUT) shall be an even power of two or zero indicating 2^{16}, so that there are an even number of bits in the LUT input. The third value (number of bits in the LUT Data) shall be 8. See C.11.1.1.
>>LUT Data	(0028,3006)	1	LUT Data
ICC Profile	(0028,2000)	1C	An ICC Profile encoding the transformation of device-dependent color stored pixel values into PCS-Values. When present, defines the color space of the output of the Volumetric Presentation State. See C.11.15.1.1 Required if Pixel Presentation (0008,9205) has a value of TRUE_COLOR.
Color Space	(0028,2002)	1C	A label that identifies the well-known color space of the view. Shall be consistent with the ICC Profile (0028,2000) that is present. Required if Pixel Presentation (0008,9205) has a value of TRUE_COLOR and a standard color space described by one of the Enumerated Values in C.11.15.1.2 is used.

Item #7: Changes to PS3.3 Annex C

C.11.23 Volumetric Presentation State Relationship Module

Table C.11.23-1 contains Attributes that describe sets of inputs to a presentation state and how each input is to be displayed in the presentation.

330 **Table C.11.23-1**
VOLUMETRIC PRESENTATION STATE RELATIONSHIP MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Volumetric Presentation Input Set Sequence	**(0070,120A)**	**1**	**Input sets specified for use by this Volumetric Presentation State**
>Volumetric Presentation Input Set UID	**(0070,1209)**	**1**	**Unique identifier of this input specification.** **See C.11.23.4.**
>Presentation Input Type	**(0070,1202)**	**1**	**Type of input.** **See C.11.23.1.** **Enumerated Value:** **VOLUME**
>Referenced Image Sequence	**(0008,1140)**	**1C**	**The set of images comprising this input volume. One or more items shall be included in this sequence.** **See C.11.23.1 for constraints on objects referenced by this sequence.** **Required if Presentation Input Type (0070,1202) has a value of VOLUME.**
>>Include 'Image SOP Instance Reference Macro' Table 10-3			
>Referenced Spatial Registration Sequence	**(0070,0404)**	**1C**	**A reference to a Spatial Registration Instance that is used to register the referenced inputs.** **Only one item shall be included in this sequence.** **All images referenced by the Referenced Image Sequence (0008,1140) of this item of the Volumetric Presentation Input Set Sequence (0070,120A) shall be referenced by the Spatial Registration instance.** **See C.11.23.3.** **Required if the Frame of Reference UID (0020,0052) value of the Images referenced by the Referenced Image Sequence (0008,1140) of this item of the Volumetric Presentation Input Set Sequence (0070,120A) does not match the Frame of Reference UID (0020,0052) value of this Presentation State instance. May be present otherwise.**
>>Include SOP Instance Reference Macro Table 10-11			

Attribute Name	Tag	Type	Attribute Description
Volumetric Presentation State Input Sequence	(0070,1201)	1	Inputs to the Presentation State. Each item represents one input. One or more items shall be included in this sequence.
>Volumetric Presentation Input Number	(0070,1207)	1	Identification number of the input. Values shall be ordinal numbers starting from 1 and monotonically increasing by 1 within the Presentation State instance.
>Volumetric Presentation Input Set UID	**(0070,1209)**	**1**	**Unique identifier of this input in Volumetric Presentation Input Set Sequence (0070,120A).** **The UID may be shared among multiple Volumetric Presentation State Input Sequence (0070,1201) items.** **See C.11.23.4.**
~~**>Presentation Input Type**~~	~~**(0070,1202)**~~	~~**1**~~	~~**Type of input.**~~ ~~**See C.11.23.1.**~~ ~~**Enumerated Value:**~~ ~~**VOLUME**~~
>Input Sequence Position Index	(0070,1203)	1C	Position of this input data within a set of sequential inputs. Multiple inputs may share the same value. Note: For example, CT and PET inputs. Distinct values shall be ordinal numbers starting from 1 and monotonically increasing by 1 within the Volumetric Presentation State instance. See C.11.23.2. Required if Presentation Animation Style (0070,1A01) is present with a value of INPUT_SEQ. Note: The inputs of the sequence are typically temporally related.
~~**>Referenced Image Sequence**~~	~~**(0008,1140)**~~	~~**1C**~~	~~**The set of images comprising this input volume. One or more items shall be included in this sequence.**~~ ~~**See C.11.23.1 for constraints on objects referenced by this sequence.**~~ ~~**Required if Presentation Input Type (0070,1202) has a value of VOLUME.**~~

Attribute Name	Tag	Type	Attribute Description
~~***>>Include 'Image SOP Instance Reference Macro' Table 10-3***~~			
~~**>Referenced Spatial Registration Sequence**~~	~~**(0070,0404)**~~	~~**1C**~~	~~**A reference to a Spatial Registration Instance that is used to register the referenced inputs.**~~ ~~**Only one item shall be included in this sequence.**~~ ~~**All images referenced by the Referenced Image Sequence (0008,1140) of this item of the Volumetric Presentation State Input Sequence (0070,1201) shall be referenced by the Spatial Registration instance.**~~ ~~**See C.11.23.3.**~~ ~~**Required if the Frame of Reference UID (0020,0052) value of the Images referenced by the Referenced Image Sequence (0008,1140) of this item of the Volumetric Presentation State Input Sequence (0070,1201) does not match the Frame of Reference UID (0020,0052) value of this Presentation State instance. May be present otherwise.**~~
~~***>>Include SOP Instance Reference Macro Table 10-11***~~			
>Include VOI LUT Macro Table C.11-2b			
>Crop	(0070,1204)	1	Specifies whether to ~~**crop**~~ **apply per-input cropping to** this input. Enumerated Values: YES NO **See C.11.23.5.**
>Cropping Specification Index	(0070,1205)	1C	Values of Cropping Specification Number (0070,1309) of the item in the Volume Cropping Sequence (0070,1301) specifying the cropping methods to be applied to this input. Required if Crop (0070,1204) has a value of YES.

Attribute Name	Tag	Type	Attribute Description
>~~**Compositing**~~ **Rendering** Method	~~**(0070,1206)**~~ **(0070,120D)**	1C	The rendering method for this input. Enumerated values: AVERAGE_IP: A method that projects the mean intensity of all interpolated samples that fall in the path of each ray traced from the viewpoint to the plane of projection. MAXIMUM_IP: A method that projects the interpolated sample with maximum intensity that falls in the path of each ray traced from the viewpoint to the plane of projection. MINIMUM_IP: A method that projects the interpolated sample with minimum intensity that falls in the path of each ray traced from the viewpoint to the plane of projection. Required if MPR Thickness Type (0070,1502) ~~**has**~~ **is present with** a value of SLAB.
Global Crop	**(0070,120B)**	**1**	**Specifies whether to apply the cropping specified by Global Cropping Specification Index (0070,120C) to every input of the Volumetric Presentation State.** **Enumerated Values:** **YES** **NO** **See C.11.23.5.**
Global Cropping Specification Index	**(0070,120C)**	**1C**	**Values of Cropping Specification Number (0070,1309) of one or more items in the Volume Cropping Sequence (0070,1301) specifying the cropping methods to be applied to every input.** **Volume Cropping Method (0070,1302) shall include only BOUNDING_BOX or OBLIQUE_PLANE values.** **Required if Global Crop (0070,120B) has a value of YES.**

C.11.23.1 Presentation Input Type VOLUME Input Requirements

SOP instances with Presentation Input Type (0070,1202) value of VOLUME referenced by one item in Volumetric Presentation ~~**State**~~ Input **Set** Sequence (0070,~~**1201**~~**x20A**) are a collection of image instances or frames within image instances that conforms to the following requirements:

- …
- Photometric Interpretation (0028,0004) shall be MONOCHROME2
- **Pixel Data (7FE0,0010) is present**

- All Instances or Frames have orthogonal row and column vectors
- …

C.11.23.4 Volumetric Presentation Input Set UID

Each set of instances and/or frames used as input to the Volumetric Presentation State specified by one item in Volumetric Presentation State Input Set Sequence (0070,120A) is identified by Volumetric Presentation Input Set UID (0070,1209). The Volumetric Presentation State Input Sequence (0070,1201) references items in Volumetric Presentation Input Set Sequence (0070,120A) by their UID and specifies the particular processing to be performed prior to compositing with other inputs to build the final presentation view.

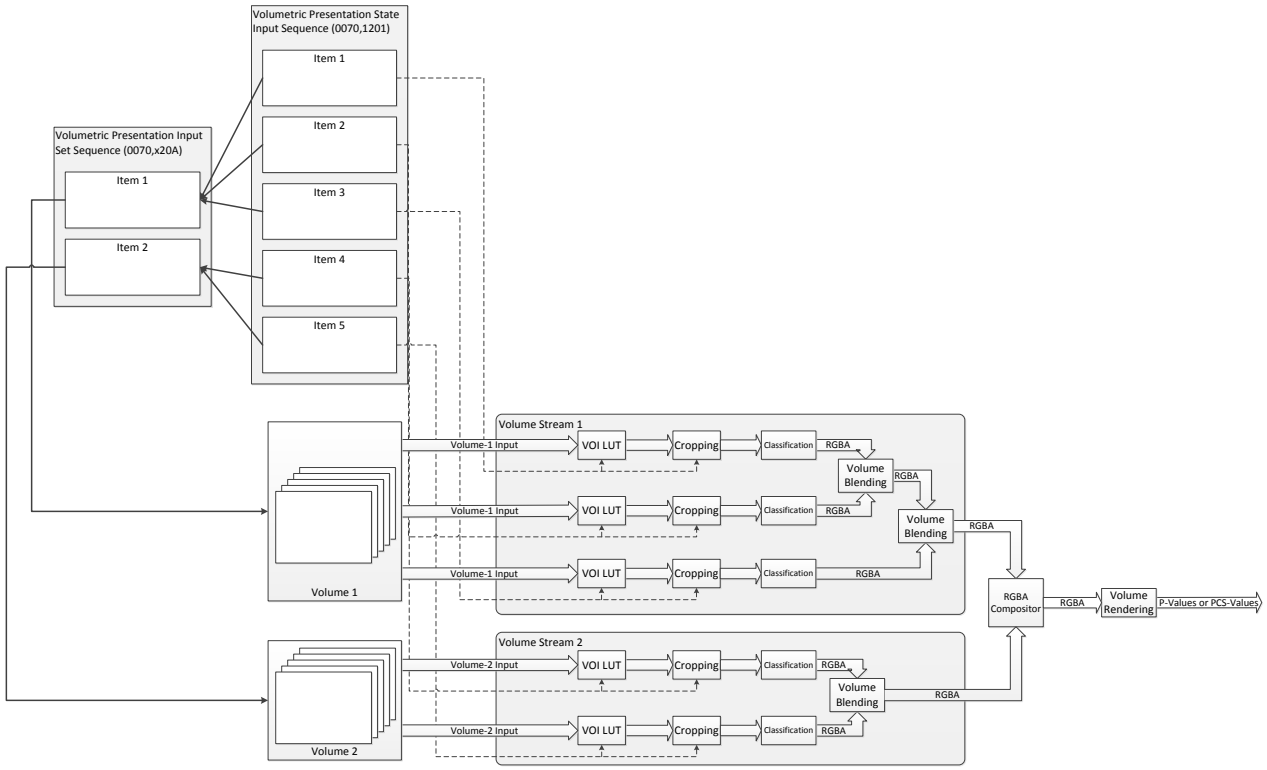

Figure C.11.23-x1 Role of Volumetric Presentation Input Set Sequence (0070,120A)

Volumetric Presentation Input Set UID (0070,1209) may be shared among multiple Volumetric Presentation State instances using the same input data.

C.11.23.5 Cropping

Cropping is an operation in which a portion of the source volume is ignored during subsequent volumetric processing. Cropping shall be specified as follows:

- **If Global Crop (0070,120B) is YES, Global Crop Specification Index (0070,120C) specifies cropping which shall be applied to every input of the Volumetric Presentation State.**
- **If Crop (0070,1204) is YES for a particular input, Cropping Specification Index (0070,1205) specifies cropping which shall be applied to that input of the Volumetric Presentation State.**

Each value in Global Crop Specification Index (0070,120C) and Cropping Specification Index (0070,1205) shall match a Cropping Specification Number (0070,1302) in Volume Cropping Sequence (0070,1301)).

C.11.26.1.1 Planar Style

…

The following attributes describe the PLANAR MPR:

- MPR View Width Direction (0070,1507) and MPR View Height Direction (0070,1511) specify the orientation of the MPR view rectangle in the Volumetric Presentation State Reference Coordinate System
- MPR View Width (0070,1508) and MPR View Height (0070,1512) specify the size of the MPR view rectangle in the Volumetric Presentation State Reference Coordinate System
- MPR Top Left Hand Corner (0070,1505) species the position of the upper-left corner of the MPR view rectangle in the Volumetric Presentation State Reference Coordinate System
- MPR Thickness Type (0070,1502) specifies whether the MPR is created by taking a single sample for each pixel (THIN) or by creating an orthographic rendering of a slab volume with a defined thickness using the method defined by ~~**Compositing**~~ **Rendering** Method ~~**(0070,1206)**~~ **(0070,120D)** (SLAB). If the specified thickness is below an application-determined limit the resulting view shall be treated as a THIN MPR.
- MPR Slab Thickness (0070,1503) specifies the thickness of the slab if MPR Thickness Type (0070,1502) is SLAB. The slab volume is positioned such that the MPR view defined by MPR View Width Direction (0070,1507), MPR View Width (0070,1508), MPR View Height Direction (0070,1511), MPR View Height (0070,1512), and MPR Top Left Hand Corner (0070,1505) is at the midpoint of the slab thickness.

…

C.11.27 MPR Volumetric Presentation State Display Module

Table C.11.27-1 specifies the attributes that define the transformations of the processed **MPR** Volumetric Presentation State inputs into a single VPS display space, as described in the Volumetric Presentation State pipeline in PS3.4.

Table C.11.27-1
MPR VOLUMETRIC PRESENTATION STATE DISPLAY MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
…			
>Component Type	(0070,1802)	1	Type of component. Enumerated values: ONE_TO_RGBA TWO_TO_RGBA See C.11.27.2~~ **for description of the components corresponding to each selection**~~.
…			

Presentation State Compositor Component Sequence	(0070,1805)	2C	~~**Sequence of**~~ RGB Compositor-components ~~**in which the order of items is significant**~~. Each RGB Compositor component combines ~~**together**~~ pairs of RGB values to produce a single RGB value. **The order of items is significant.** If there is more than one compositor component, the components are chained such that the output of one compositor component is an input to the next compositor component. The number of items in this sequence shall be **one less than** the number of items in Presentation State Classification Component Sequence (0070,1801) ~~**minus one**~~. See C.11.27.3. Required if Pixel Presentation (0008,9205) has a value of TRUE_COLOR.
>Weighting Transfer Function Sequence	(0070,1806)	1	Transfer functions **used to derive the weighting factors for each of the two RGB inputs from both input Alphas.** **Each function is** ~~**each**~~ represented by the formula $f(Alpha_1, Alpha_2) = WeightingFactor$ ~~**used to derive the weighting factors for each of the two RGB inputs from both input Alphas.**~~ The function is specified in the form of a table. Two items shall be included in this sequence ~~**to produce weighting factors for RBG1 and RGB2 inputs, respectively**~~. **The order is significant. The first item specifies the weighting factor for RGB1 and the second item specifies the weighting factor for RGB2.** See C.11.27.4.
>>LUT Descriptor	(0028,3002)	1	Specifies the format of the LUT Data (0028,3006) in this Sequence. The first value (number of entries in the LUT) shall be an even power of two or zero indicating 2^{16}, so that there are an even number of bits in the LUT input. The third value (number of bits in the LUT Data) shall be 8. See C.11.1.1.
>>LUT Data	(0028,3006)	1	LUT Data ~~**in this Sequence**~~.

…			
Color Space	**(0028,2002)**	**1C**	**A label that identifies the well-known color space of the view.** **Shall be consistent with the ICC Profile (0028,2000) that is present.** **Required if Pixel Presentation (0008,9205) has a value of TRUE_COLOR and a standard color space described by one of the Enumerated Values in C.11.15.1.2 is used.**

C.11.29 Presentation Animation Module

Table C.11.29-1 contains Attributes that describe animation of the presentation.

Table C.11.29-1
PRESENTATION ANIMATION MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Presentation Animation Style	(0070,1A01)	1	Animation style ~~**intended by the source.**~~ Defined Terms: INPUT_SEQ PRESENTATION_SEQ CROSSCURVE **FLYTHROUGH** **SWIVEL** See C.11.29.1-~~**for description of terms**~~.
Recommended Animation Rate	(0070,1A03)	3	Recommended rate at which the inputs shall be displayed. Shall have a value greater than zero. See C.11.29.1-~~**for units**~~.

Animation Curve Sequence	(0070,1A04)	1C	Curve describing the trajectory of a flythrough animation. Only one Item shall be included in this sequence. Required if Presentation Animation Style (0070,1A01) is CROSSCURVE **or FLYTHROUGH**.
>Number of Volumetric Curve Points	(0070,150C)	1	Number of (x,y,z) points in Volumetric Curve Points (0070,150D).
>Volumetric Curve Points	(0070,150D)	~~1C~~ **1**	Coordinates of points on the curve in the Volumetric Presentation State Reference Coordinate System, in mm. One triplet (x,y,z) shall be present for each point in the curve. **See C.11.29.1.** Note: The points on the curve are samples. It is an implementation decision how the points are connected.
>Volumetric Curve Up Directions	**(0070,1A07)**	**1C**	**Direction cosines (x_d,y_d,z_d) in the Volumetric Presentation State Reference Coordinate System defining the viewpoint up direction at each point in Volumetric Curve Points (0070,150D).** **See C.11.29.1.** **Required if Presentation Animation Style (0070,1A01) has a value of FLYTHROUGH.**
Animation Step Size	(0070,1A05)	1C	Distance in mm along the curve the display moves in one step. Required if Presentation Animation Style (0070,1A01) has a value of CROSSCURVE **or FLYTHROUGH**.
Swivel Range	**(0070,1A06)**	**1C**	**Range in which a volume rotates back-and-forth around the swivel axis, in degrees. The initial position is at the midpoint of the swivel range.** **See C.11.29.1.** **Required if Presentation Animation Style (0070,1A01) is SWIVEL.**

…

C.11.29.1 Presentation Animation Style

The presence of Presentation Animation Style (0070,1A01) indicates that a form of view animation is intended by the creator of the Presentation State, and the value of the attribute indicates the nature of such animation. See PS3.4 Section X.3.2 for further description of the various presentation animation styles.

Values of Presentation Animation Style (0070,1A01) are:

- …
- **FLYTHROUGH: Indicates that the field of view defined by Render Field of View (0070,1606) be stepped along the curve defined in Animation Curve Sequence (0070,1A04) at the rate specified by Recommended Animation Rate (0070,1A03) steps per second. Presentation Animation Style (00070,1A01) value of FLYTHROUGH shall be present only if Render Projection (0070,1602) is present.**

  Viewpoint LookAt Point (0070,1604) shall coincide with the first point in Volumetric Curve Points (0070,150D, the direction from the Viewpoint Position (0070,1603) to the Viewpoint LookAt Point(0070,1604) shall be tangent to the curve at that point, and the Viewpoint Up Direction (0070,1605) shall be parallel to the first direction cosine in Volumetric Curve Up Directions (0070,1A07).

  Note: These conditions ensure the view defined by the Volumetric Presentation State matches the initial view of the animation.

  Spacing of curve points in Volumetric Curve Points (0070,150D) shall be chosen such that the angular change between any two consecutive direction cosines in Volumetric Curve Up Directions (0070,1A07) is always less than 90 degress in 3D space, and should be chosen such that the change in curve direction at each point is reasonably small.

  Note: This condition and recommendation ensure that the up direction interpolated between points in Volumetric Curve Points (0070,150D) and the direction along the tangent from viewpoint to lookAt point at each step are always unambiguous.

  The animation consists of a sequence of dynamically repositioned views that are successively rendered to produce a moving view along a curve through the volume. The curve is specified by the set of discrete points defined by Volumetric Curve Points (0070,150D). The views are at points along the curve determined by Animation Step Size (0070,1A04) and may or may not correspond to Volumetric Curve Points (0070,150D). At each step in the sequence, the viewpoint position, lookAt, and up direction changes as follows:

  - **The distance D_{lookAt} is the distance between Viewpoint Position (0070,1603) and Viewpoint LookAt Point (0070,1604), which is a constant throughout the animation.**
  - **The view lookAt point is initially the first point in Volumetric Curve Points (0070,150D). At each step in the animation, the lookAt point moves on the curve a distance defined by Animation Step Size (0070,1A04) from the previous lookAt point in the direction towards the last point in Volumetric Curve Points (0070,150D).**
  - **At each lookAt point position:**
    - **There is a line L_{tan} tangent to the curve at the currentLookAt point.**
    - **The viewpoint is a point on L_{tan} at a distance D_{lookAt} from the lookAt point. The direction from viewpoint to lookAt point is looking forward along the curve, generally toward the next point in Volumetric Curve Points (0070,150D).**
    - **If the current lookAt point is coincident with a point in Volumetric Curve Points (0070,150D), the up direction is the direction cosine in Volumetric Curve Up Direction (0070,1A07) corresponding to that point. Otherwise, the up direction is the direction interpolated between the two direction cosines in Volumetric Curve Up Directions (0070,1A07) corresponding to the neighboring points in Volumetric Curve Points (0070,150D).**
    - **The field of view is defined by Render Field of View (0070,1606) relative to the viewpoint coordinate system determined by the current viewpoint, lookAt point, and up direction.**
- **SWIVEL: Indicates that the rendered volume rotates around the "swivel axis", which is defined as the axis parallel to the Viewpoint Up Direction (0070,1605) intersecting the**

Viewpoint LookAt Point (0070,1604). The rendered volume rotates back and forth in the angular range specified by Swivel Range (0070,1A06) at a rotational frequency specified by Recommended Animation Rate (0070,1A03) in degrees per second. The display application should provide for smooth (rather than abrupt) changes in direction as the swivel approaches the limits of the swivel range. Shall not be used unless Render Projection (0070,1602) is present.

Note: There are no constraints on the value of Swivel Range (0070,1A06). If this value is greater than 360 degrees, it implies that the rendered volume rotates more than one full rotation before changing direction. There is no significance given to negative rather than positive values of Swivel Range (0070,1A06).

Changes to NEMA Standards Publication PS3.4-2016e
Digital Imaging and Communications in Medicine (DICOM)
Part 4: Service Class Specifications

Item #8: Change to PS3.4 Section 2

2 Normative References

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[Porter-Duff 1984] SIGGRAPH '84 Proceedings of the 11th annual conference on Computer graphics and interactive techniques. T. Porter and T Duff 1984, 253-259 "Compositing Digital Images"

Item #9: Add SOP Classes to PS3.4 Annex B

B.5 Standard SOP Classes

Table B.5-1
Standard SOP Classes

SOP Class	SOP Class UID	IOD Specification (defined in PS3.3)
Volume Rendering Volumetric Presentation State Storage	**1.2.840.10008.5.1.4.1.1.11.9**	**Volume Rendering Volumetric Presentation State IOD**
Segmented Volume Rendering Volumetric Presentation State Storage	**1.2.840.10008.5.1.4.1.1.11.10**	**Volume Rendering Volumetric Presentation State IOD**
Multiple Volume Rendering Volumetric Presentation State Storage	**1.2.840.10008.5.1.4.1.1.11.11**	**Volume Rendering Volumetric Presentation State IOD**

B.5.1.19 Planar MPR Volumetric Presentation State Storage SOP Classes

The requirements of Annex FF**.2.1.1** apply to the following SOP Classes:

- Grayscale Planar MPR Volumetric Presentation State Storage
- Compositing Planar MPR Volumetric Presentation State Storage

…

B.5.1.24 Volume Rendering Volumetric Presentation State Storage SOP Classes

The requirements of Annex FF.2.1.2 apply to the following SOP Classes:

- **Volume Rendering Volumetric Presentation State SOP Class**
- **Segmented Volume Rendering Volumetric Presentation State SOP Class**
- **Multiple Volume Rendering Volumetric Presentation State SOP Class**

The Volume Rendering Volumetric Presentation State Storage SOP Class shall use the Volume Rendering Volumetric Presentation State IOD and include a single item in Volumetric Presentation

State Input Sequence (0070,1201) and a single item in Volume Stream Sequence (0070,1A08). Also, the value of Crop (0070,1204) shall be NO.

The Segmented Volume Rendering Volumetric Presentation State Storage SOP Class shall use the Volume Rendering Volumetric Presentation State IOD and include a single item in Volume Stream Sequence (0070,1A08).

The Multiple Volume Rendering Volumetric Presentation State Storage SOP Class shall use the Volume Rendering Volumetric Presentation State IOD and include two or more items in Volume Stream Sequence (0070,1A08).

Item #10: Modifications to PS3.4 Annex FF

FF Volumetric Presentation State Storage SOP Classes (Normative)

FF.1 Overview

FF.1.1 Scope

The Volumetric Presentation State Storage SOP Classes extend the functionality of the Storage Service class (defined in Annex B) to add the ability to convey an intended Volumetric Presentation State or record an existing Volumetric Presentation State. The SOP Classes specify the information and behavior that may be used to present (display) images that are referenced from within the SOP Classes.

They include capabilities for specifying:

- spatial registration on the input datasets
- cropping of the volume datasets by a bounding box, oblique planes and segmentation objects
- the generation geometry of volumetric views
- **shading models**
- scalar to P-Value or RGB Value conversions
- compositing of multiple **MPR** renderings
- **compositing of multiple volume streams and one volume stream with segmentation**
- clinical description of the specified view
- volume and display relative annotations, including graphics, text and overlays **plus optional references to structured content providing clinical context for annotations**
- membership to a collection of related Volumetric Presentation States intended to be processed or displayed together
- the position within a set of **sequentially** related Volumetric Presentation States
- animation of the view
- reference to an image depicting the view described by the **Volumetric** Presentation State

Each Volumetric Presentation State corresponds to a single view (equivalent to an Image Box in a Hanging Protocol or Structured Display). If multiple Volumetric Presentation States are intended to be displayed together (e.g. a set of orthogonal MPR views) these Presentation States can be grouped by assigning them to a Display Collection. However, any detailed information about how a set of views should be presented can only be described by a Structured Display instance or a Hanging Protocol.

The Planar MPR Volumetric Presentation State refers to the multi-planar geometry and grayscale or color image transformations that are to be applied in an explicitly defined manner to convert the stored image

pixel data values in a Composite Image Instance to presentation values (P-Values) or Profile Connection Space values (PCS-Values) when an image is displayed on a softcopy device.

The Volume Rendering Volumetric Presentation State specifies a volume rendered view of volume data. Volume Rendering is a data visualization method in which voxels (volume sample points) are assigned a color and an opacity (alpha), and a 2D view is created by accumulating a set of non-transparent samples along a ray through the volume behind each pixel of the view. Ray samples are calculated by interpolating the voxel values in the neighborhood of each sample.

Volume Rendering generally consists of a number of steps, many of which are parametrically specified in the Volume Rendering SOP Classes. The processing steps are:

- **Segmentation, or separating the volume data into groups that will share a particular color palette. Segmentation objects are specified as cropping inputs to the Volumetric Presentation State.**
- **Gradient Computation, or finding edges or boundaries between different types of tissue in the volumetric data. The gradient computation method used is an implementation decision outside the scope of the Volumetric Presentation State.**
- **Resampling of the volumetric data to create new samples along the imaginary ray behind each pixel in the output two-dimensional view, generally using some interpolation of the values of voxels in the neighborhood of the new sample. The interpolation method used is an implementation decision outside the scope of the Volumetric Presentation State.**
- **Classification of samples to assign a color and opacity to each sample.**
- **Shading or the application of a lighting model to samples indicating the effect of ambient, diffuse, and specular light on the sample.**
- **Compositing or the accumulation of samples on each ray into the final value of the pixel corresponding to that ray. The specific algorithms used are outside the scope of the Volumetric Presentation State.**
- **Conversion to presentation Profile Connection Space values (PCS-Values) when an image is displayed on a softcopy device.**

The result of applying a Volumetric Presentation State is not expected to be exactly reproducible on different systems. It is difficult to describe the display and rendering algorithms in enough detail in an interoperable manner such that a presentation produced at a later time is indistinguishable from that of the original presentation. While Volumetric Presentation States use established DICOM concepts of grayscale and color matching (GSDF and ICC color profiles) and provide a generic description of the different types of display algorithms possible, variations in algorithm implementations within display devices are inevitable and an exact match of volume presentation on multiple devices cannot be guaranteed. Nevertheless, reasonable consistency is provided by specification of inputs, geometric descriptions of spatial views, type of processing to be used, color mapping and blending, input fusion, and many generic rendering parameters, producing what is expected to be a clinically acceptable result.

The P-Values are in a device independent perceptually linear space that is formally defined in PS3.14 Grayscale Standard Display Function. The PCS-Values are in a device independent space that is formally defined in the ICC Profiles as CIEXYZ or CIELab values.

How an SCP of these SOP Classes chooses between multiple Presentation State instances that may apply to an image is beyond the scope of this standard.

A claim of conformance as an SCP of the SOP Class implies that the SCP shall make the Presentation State available to the user of the device, and if selected by the user, shall apply all the transformations stored in the state in the manner in which they are defined in the standard.

How an SCP of these SOP Classes chooses to display multiple states that are part of a Display Collection is beyond the scope of this standard.

Note: For example, if a user selects a state that is part of a four state Spatial Collection, an SCP may choose to display all four together, to display the single state selected by the user or to display two of the four states deemed appropriate by the SCP.

FF.2 Volume Transformation Processes

FF.2.1 Volumetric Transformations

The transformations defined in the Volumetric Presentation State Storage SOP Classes replace those that may be defined in the Referenced Image SOP Instances. If a particular transformation is absent in a Volume Rendering Volumetric Presentation State Storage SOP Instance, then it shall be assumed to be an identity transformation and any equivalent transformation, if present, in the Referenced Image SOP Instances shall NOT be used.

The presentation-related Attributes of the Volume Rendering Volumetric Presentation State Storage SOP Classes are immutable. They shall never be modified or updated; only a derived SOP Instance with a new SOP Instance UID may be created to represent a different presentation.

~~FF.2.1~~ FF.2.1.1 Planar MPR Volumetric Transformations ~~Process~~

The Planar MPR Volumetric Presentation State Storage SOP Classes support a set of transformations to produce derived volumetric views of volume input data.

The Grayscale Planar MPR Volumetric Presentation State Storage SOP Class defines a grayscale volumetric view from a single volume input. The sequence of transformations from volumetric inputs into P-Values is explicitly defined in the reference pipeline described in Figure FF.2-1.

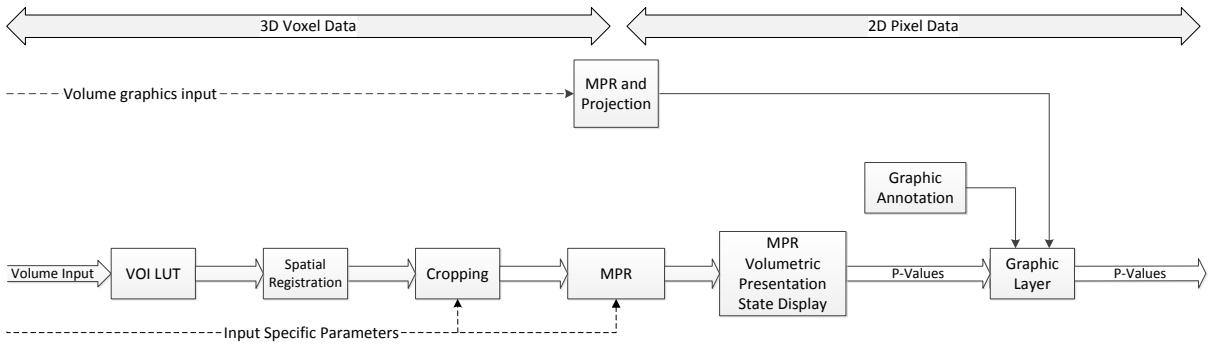

Figure FF.2-1. Grayscale Planar MPR Volumetric Pipeline

The Compositing Planar MPR Volumetric Presentation State Storage SOP Class defines a true color volumetric view from one or more volume inputs. The sequence of transformations from volumetric inputs into PCS-Values is explicitly defined in the reference pipeline described in Figure FF.2-2. The actual sequence implemented may differ (such as classifying and compositing prior to creating the MPR view) but must result in similar appearance.

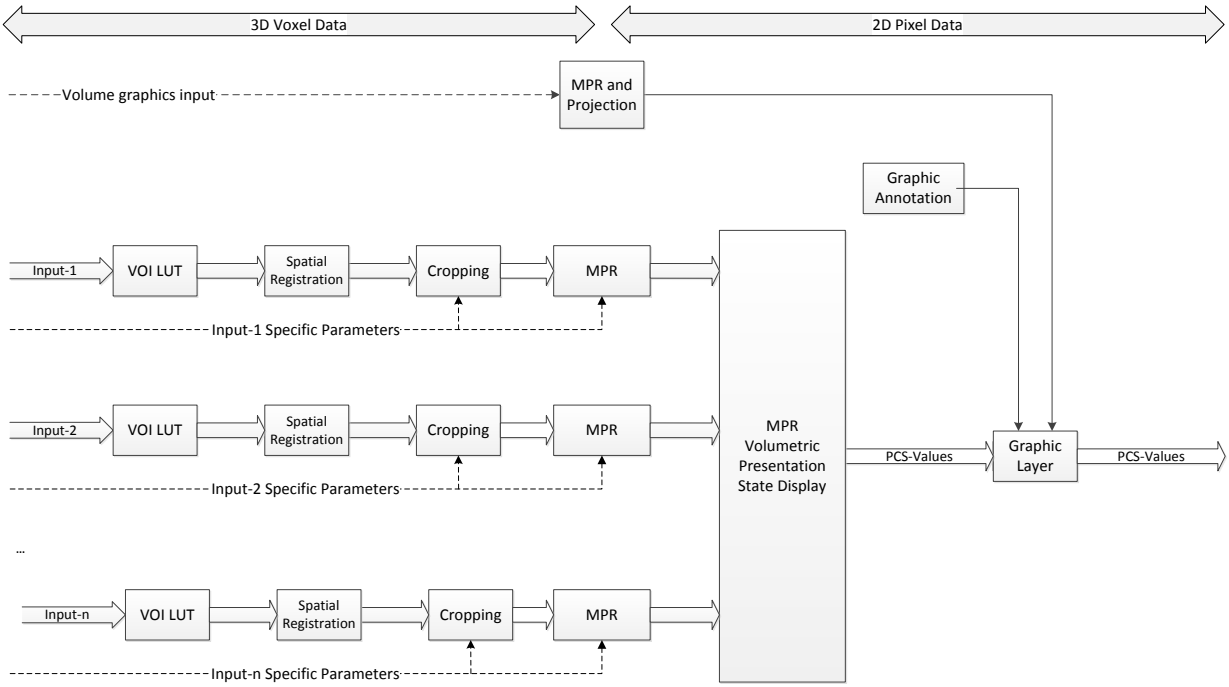

Figure FF.2-2. Compositing Planar MPR Volumetric Pipeline

~~**The transformations defined in the Planar MPR Volumetric Presentation State Storage SOP Classes replace those that may be defined in the Referenced Image SOP Instances. If a particular transformation is absent in a Planar MPR Volumetric Presentation State Storage SOP Classes then it shall be assumed to be an identity transformation, and any equivalent transformation, if present, in the Referenced Image SOP Instances shall NOT be used instead.**~~

~~**The presentation-related Attributes of the Planar MPR Volumetric Presentation State Storage SOP Classes are immutable. They shall never be modified or updated; only a derived SOP Instance with a new SOP Instance UID may be created to represent a different presentation.**~~

The planar MPR transformation requires a volume that is in the Volumetric Presentation State Reference Coordinate System (VPS-RCS).

MPR generation is based on the attributes of the Multi-Planar Reconstruction Geometry Module (see Section C.11.26.1.1 "Planar Style" in PS3.3). If the MPR Thickness Type (0070,1502) is SLAB then the Rendering Method (0070,120D) is also used.

If Pixel Presentation (0008,9205) is MONOCHROME, then Presentation LUT Shape (2050,0020) provides the transform to output P-Values.

If Pixel Presentation (0008,9205) is TRUE_COLOR, then Presentation State Classification Component Sequence (0070,1801) describes the conversion of each processed input into an RGB data stream, and Presentation State Compositor Component Sequence (0070,1805) describes the compositing of these separate RGBA data streams into a single RGB data stream. This single RGB data stream is then processed as described by ICC Profile (0028,2000) to produce output PCS-Values.

FF.2.1.2 Volume Rendering Volumetric Transformations

FF.2.1.2.1 Volume Rendering Pipelines

The Volume Rendering Volumetric Presentation State Storage SOP Classes support a set of transformations to produce derived volumetric views of volume input data. Attributes comprising the Volume Rendering Volumetric Presentation States are defined in the context of the reference pipelines described in this section. While the reference pipelines imply a certain order of the volume rendering operations of classification, resampling, shading, and compositing, the specific order in which these operations are applied by any device claiming conformance to this standard are implementation-dependent and beyond the scope of this standard. It is the responsibility of the viewing application to transform the standard attributes into parameters appropriate for the particular order of operations implemented in the viewing application.

The Volume Rendering Volumetric Presentation State Storage SOP Class defines a volumetric view from a single volume input to produce a volume rendered view. The sequence of transformations from volumetric inputs into PCS-Values is explicitly defined in the reference pipeline described in Figure FF.2-x1.

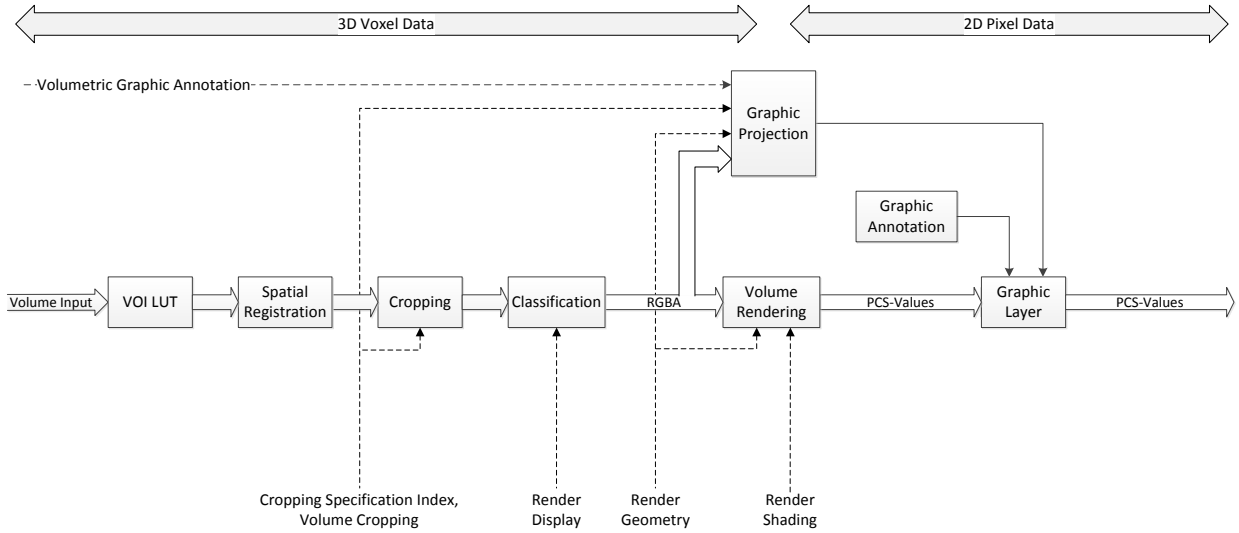

Figure FF.2-x1: Volume Rendering Volumetric Pipeline

The Segmented Volume Rendering Volumetric Presentation State Storage SOP Class defines a volumetric view from a single volume dataset with optional segmentation croppings, each colored separately and blended into the volume to be rendered. The sequence of transformations from volumetric inputs into PCS-Values is explicitly defined in the reference pipeline described in Figure FF.2-x2.

There is a single item in the Volume Stream Sequence (0070,1A08) for instances of this SOP Class.

The classified segmented volumes shall be blended in lowest to highest priority order using B-over-A blending of the RGB data and the corresponding opacity (alpha) data. The first item in the Presentation State Classification Component Sequence (0070,1801) is the base upon which subsequent items are cropped and B-over-A blended with it.

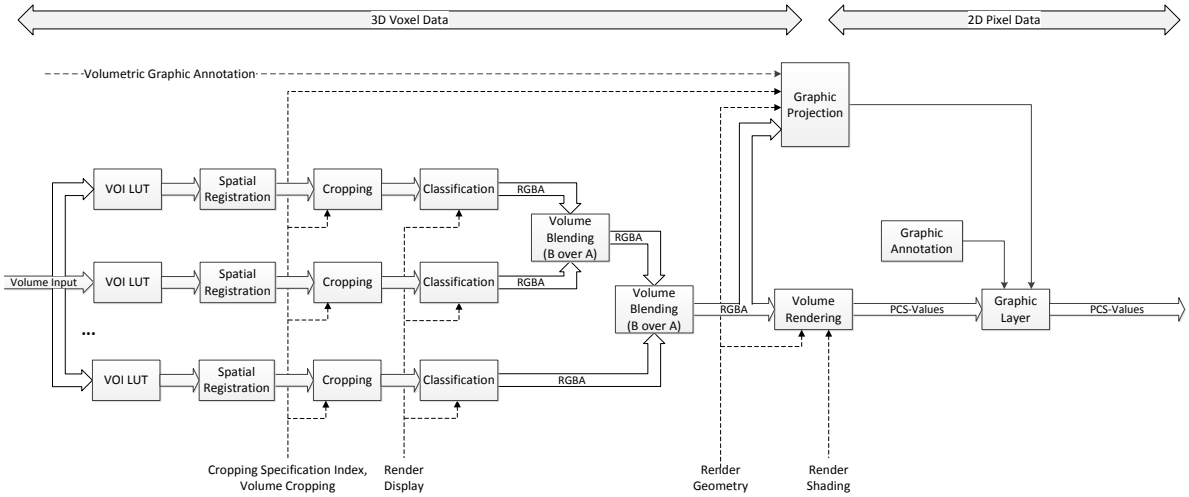

Figure FF.2-x2: Segmented Volume Rendering Volumetric Pipeline

The Multiple Volume Rendering Volumetric Presentation State Storage SOP Class defines a volumetric view from more than one volume input. The sequence of transformations from volumetric inputs into PCS-Values is explicitly defined in the reference pipeline described in Figure FF.2-x3. The specific algorithms for volume rendering may differ, but must result in a similar appearance.

It is expected that all volume inputs are spatially registered to the Volumetric Presentation State – Reference Coordinate System. The specific step in the processing at which resampling is performed to achieve this spatial registration is an implementation decision.

Each item in the Volume Stream Sequence (0070,1A08) produces one input to a RGBA Compositor.

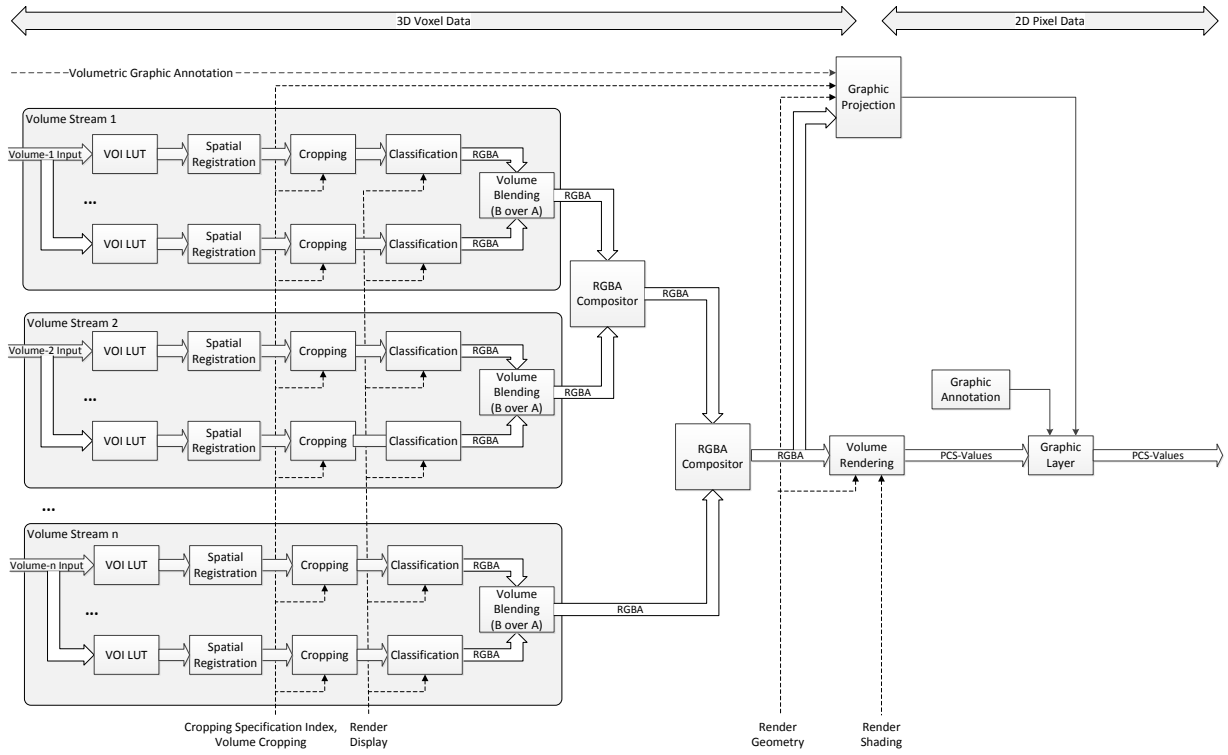

Figure FF.2-x3: Multiple Volume Rendering Volumetric Pipeline

Transformation to PCS-Values is performed after Volume Rendering.

FF.2.1.2.2 Volume Rendering Component

This component transforms an RGBA volume into a volume rendered view according to the parameters in the Render Geometry Module. This component is implementation dependent, but generally includes processing steps such as gradient computation to find normals of use in the shading operation, resampling of volume data, shading according to the parameters in the Render Shading Module, and compositing of the resampled data to produce the final volume rendered view.

FF.2.1.2.3 Graphic Projection Component

This component converts the volumetric annotation specified in the Volumetric Graphic Annotation module into a graphic overlay for the 2D volume rendered view. It is the role of this component to evaluate the volumetric graphic annotations, determine which graphics are visible in the volume rendered view, and provide graphics that are layered on the view.

Inputs to the Graphic Projection component are:

- **Volumetric Graphic Annotation module**
- **RGBA volume input to the Volume Rendering component**
- **Volume Render Geometry module**
- **Input-specific Cropping Specification Index (0070,1205) values**
- **Volume Cropping module elements**

The Graphic Projection transform algorithm considers whether each volumetric graphic annotation is visible in the current volume rendered view, considering the volume data, Volume Render Geometry, and the value of Annotation Clipping (0070,1907).

If Annotation Clipping (0070,1907) is YES, then the annotation shall be visible only if it is present in the field of view and not obscured by opaque structures that may lie between the annotation and the viewpoint. In the case of the Volumetric Presentation Input Annotation Sequence (0070,1905), annotation text shall be visible only if some part of the specified segmentation is visible.

If Annotation Clipping (0070,1907) is NO, then the annotation shall always be visible. A partiicular implementation may display annotations that lie behind opaque structures in a different style (such as a softer gray), but the decision to provide such display style is outside the scope of this standard.

The output of the Graphic Projection component is displayed on the 2D presentation view in the graphic layers specified by the corresponding values of Graphic Layer (0070,0002).

~~FF.2.1.1~~ FF.2.2 Volumetric Inputs, Registration and Cropping

A Volumetric Presentation State can take multiple volumes as input. A volume is defined in Section C.11.23.1 "Presentation Input Type Volume Input Requirements" in PS3.3. The same source data can be referenced in more than one input.

The VOI LUT **encoded in the Volumetric Presentation State** is applied to the input data.

The input volumes may or may not be in the Volumetric Presentation State Reference Coordinate System (VPS-RCS). If they are not, they shall be registered into the VPS-RCS.

~~The input volumes shall be cropped~~ **Two methods of cropping the input volumes are provided:**

- **All inputs to the Volumetric Presentation State may be cropped using the common cropping methods specified by Global Crop (0070,120B) and items in the Volume Cropping Sequence (0070,1301).**
- **In addition, cropping may be specified independently for each input to the Volumetric Presentation State** as specified by the value of Crop (0070,1204) and items in the Volume Cropping Sequence (0070,1301).

Note: Combinations of cropping methods may be specified. For example, all inputs could be cropped using global bounding box cropping in addition to another cropping method applied to one of more individual inputs to the Volumetric Presentation State.

~~**FF.2.1.2 Volumetric Transformations**~~

~~**FF.2.1.2.1 Planar MPR Volumetric Presentation State**~~

~~**The planar MPR transformation requires a volume that is in the Volumetric Presentation State Reference Coordinate System (VPS-RCS).**~~

~~**MPR generation is based on the attributes of the Multi-Planar Reconstruction Geometry Module (see Section C.11.26.1.1 "Planar Style" in PS3.3). If the MPR Thickness Type (0070,1502) is SLAB then the Compositing Method (0070,1206) is also used.**~~

~~FF.2.1.3~~ FF.2.3 Volumetric Presentation State Display

~~FF.2.1.3.1~~ FF.2.3.1 Volumetric Presentation State Display ~~Foundation~~ Overview

The **MPR** Volumetric Presentation State Display Module defines the algorithms used to transform the result of the **MultiPlanar Reconstruction** volumetric processing on the input data into an output of P-Values or PCS-Values for display.

~~**If Pixel Presentation (0008,9205) is MONOCHROME, then Presentation LUT Shape (2050,0020) provides the transform to output P-Values.**~~

~~**If Pixel Presentation (0008,9205) is TRUE_COLOR, then Presentation State Classification Component Sequence (0070,1801) describes the conversion of each processed input into an RGB data stream, and Presentation State Compositor Component Sequence (0070,1805) describes the compositing of these separate RGBA data streams into a single RGB data stream. This single RGB**~~

~~data stream is then processed as described by ICC Profile (0028,2000) to produce output PCS-Values.~~

The Render Display Module defines the algorithms used to transform the result of the Volume Rendering processing on the input data into output RGBA values. Presentation State Classification Component Sequence (0070,1801) describes the conversion of each cropped input into an RGBA volumetric data stream. Volume Stream Sequence (0070,1209) describes RGBA volumetric data streams which are overlayed using ordered "B over A" blending into a volumetric data stream. Presentation State Compositor Component Sequence (0070,1805) describes how the "B over A" blended volumetric data streams are to be composited together into a single RGBA volumetric data stream. This single RGBA data stream is an input to the Volume Rendering component.

FF.2.3.2 Description of Display Components

~~FF.2.1.3.1.1~~ FF.2.3.2.1 Classification Component Components

There are two classification component types currently defined for conversion from scalar input data to RGBA. The defined components are:

- One Input -> RGBA: This component accepts reconstructed data from one input in the Volumetric Presentation State Input Sequence (0070,1201) and generates an RGB and an Alpha output. This classification component would be specified in an item of the Presentation State Classification Component Sequence (0070,1801):

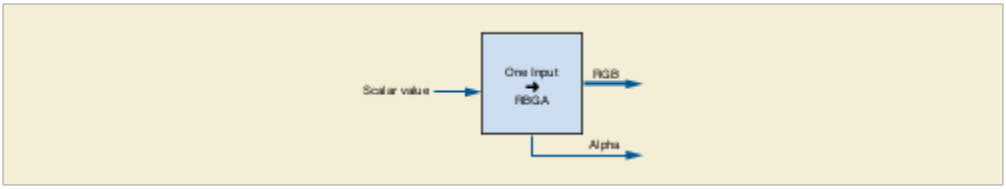

Figure FF.2-3. One Input -> RGBA Component

- Two Inputs -> RGBA: This component accepts reconstructed data from two inputs in the Volumetric Presentation State Input Sequence (0070,1201) and generates an RGB and an Alpha output. This component is used in the case where a two-dimensional color mapping needs to be performed. This classification component would be specified in an item of the Presentation State Classification Component Sequence (0070,1801):

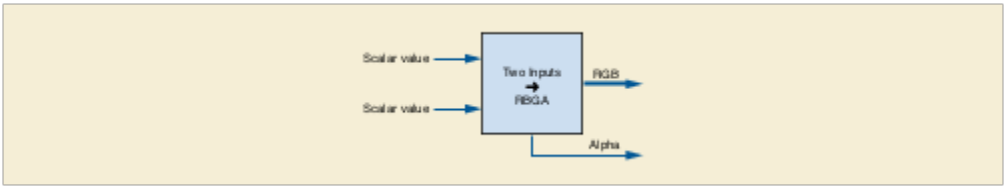

Figure FF.2-4. Two Inputs ->RGBA Component

Note

An example for the use of this component is to combine Ultrasound Flow Velocity and Ultrasound Flow Variance to produce a color range from red-blue based on flow velocity and adding a yellow-green tinge based on flow variance).

~~FF.2.1.3.1.2~~ FF.2.3.2.2 Compositor Components

There ~~is one~~ **are two** compositor component ~~type~~ **types** defined for compositing of two input RGBA (or one RGBA and one RGB) data sources ~~into an RGB output~~. The defined ~~component is~~ **components are**:

- RGB Compositor: This component accepts two RGBA inputs (with one Alpha input optional) and composites the data into a single RGB output. Each item of Presentation State Compositor Component Sequence (0070,1805) specifies one RGB Compositor component:

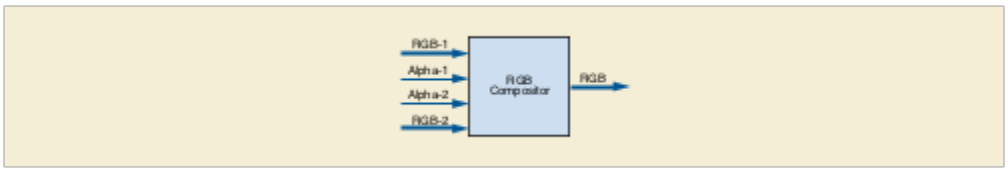

Figure FF.2-5. RGB Compositor Component

- **RGBA Compositor: This component accepts two RGBA inputs and composites the data into a single RGB output and a single Alpha output.**

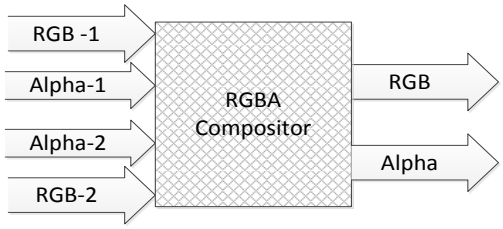

Figure FF.2-x4: RGBA Compositor Component

~~The ICC Profile Connection Space Transform operation is performed after classification and compositing to generate output PCS values using the specified ICC Color Profile (0028,2000).~~

~~FF.2.1.3.2~~ FF.2.3.3 Internal Structure of Components

~~FF.2.1.3.2.1~~ FF.2.3.3.1 Internal Structure of Classification Components

Component Type (0070,1802) specifies the component defined in each item of Presentation State Classification Component Sequence (0070,1801), which in turn controls by conditions the rest of the content of the item to provide the necessary specification of the component. The internal structure of each component in block diagram form is as follows:

- One Input -> RGBA: Specified by Component Type (0070,1802) = ONE_TO_RGBA:

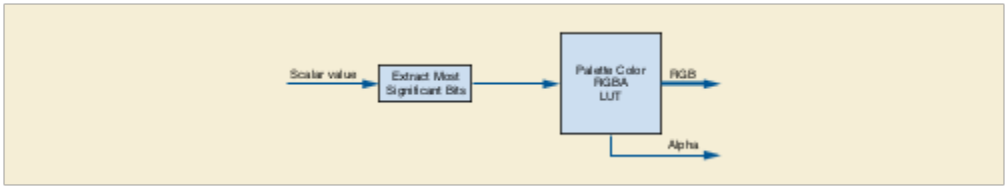

Figure FF.2-6. Internal Structure of One Input -> RGBA Component

- Two Inputs -> RGBA: If Component Type (0070,1802) = TWO_TO_RGBA:

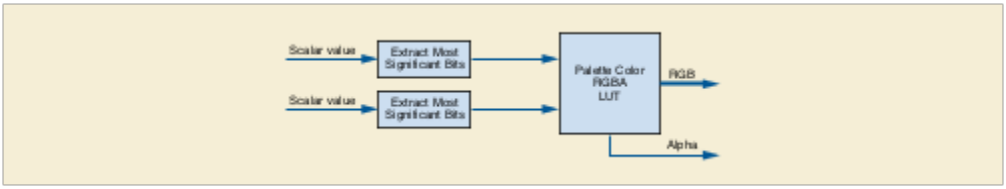

Figure FF.2-7. Internal Structure of Two Input -> RGBA Component

The number of most significant bits extracted from each input is specified by the value of Bits Mapped to Color Lookup Table (0028,1403) in the Component Input Sequence (0070,1803) item for that input.

If Component Type (0070,1802) = TWO_TO_RGBA, there shall be two items in Component Input Sequence (0070,1803) with the first item defining the source of the most significant bits of the Palette Color Lookup Table input and the second item defining the source of the least significant bits of the Palette Color Lookup Table input.

~~FF.2.1.3.2.2~~ FF.2.3.3.2 Internal Structure of RGB and RGBA Compositor Components

Weighting transfer functions that compute the weighting factors used by the Compositor Function as a function of $Alpha_1$ and $Alpha_2$ values are specified as weighting look-up tables (LUTs) in the RGB **and RGBA** Compositor ~~**component**~~ **components**. **The RGB and RGBA Compositor components are identical except for the compositing of the additional Alpha component in the RGBA Compositor**:

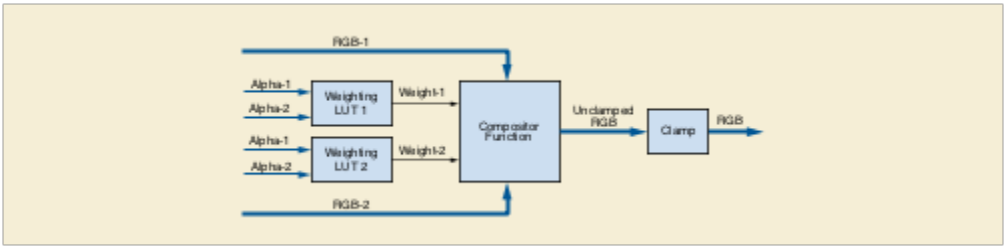

Figure FF.2-8. Internal Structure of RGB Compositor Component

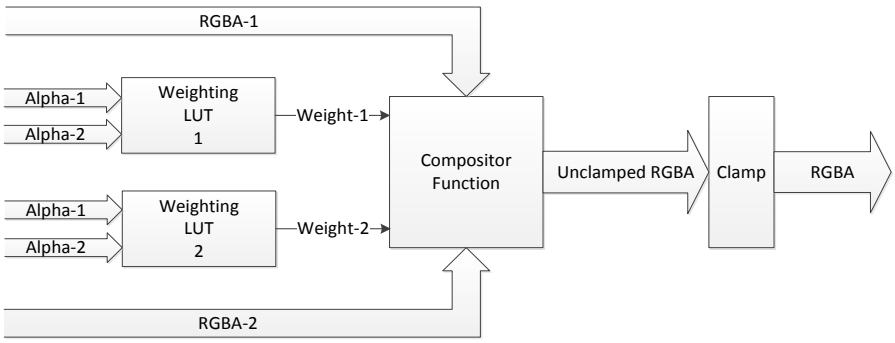

Figure FF.2-8x: Internal Structure of RGB and Opacity Compositor Component

Because each Weighting LUT uses both Alpha values in determining a weighting factor, they allow compositing functions that would not be possible if each weighting factor were based only on that input's Alpha value. See Section XXX.5 “Compositing and the Use of Weighting Transfer Functions” in PS3.17 for typical usage of the Weighting LUTs.

The input bits to the Weighting LUTs are obtained by combining the two Alpha inputs, with half the input bits obtained from each Alpha input:

- In the case of the first compositor component corresponding to the first item in Presentation State Compositor Component Sequence (0070,1805), the Alpha from the classification component corresponding to the first item in the Presentation State Classification Component Sequence (0070,1805) provides the most significant bits of the Weighting LUT inputs, while the Alpha from the classification component corresponding to the second item in the Presentation State Classification Component Sequence (0070,1805) provides the least significant bits of the Weighting LUT inputs.

- In the case of subsequent compositor components, the Alpha from the classification component corresponding to the next item in the Presentation State Classification Component Sequence (0070,1805) provides the least significant bits of the Weighting LUT inputs, while the most significant bits of the Weighting LUT inputs are computed as one minus the Alpha from the classification component corresponding to the next item in the Presentation State Classification Component Sequence (0070,1805).

The integer outputs of the Weighting LUTs are normalized to the range 0.0 to 1.0, and the Compositor Function combines the normalized R, G, ~~and~~ B**, and Alpha** (each component called "Color" = C_x) input values as follows:

$C_{out} = (C_1 * Weight_1) + (C_2 * Weight_2)$

The sum of the normalized $Weight_1$ and $Weight_2$ shall be no greater than 1.0.

The color input values are normalized because the number of output bits from the RGB Palette Color Lookup Tables **and the Alpha Palette Color Lookup Table** may be different in each classification component.

The output of the compositor shall be range-limited ("clamped") to ensure that the outputs are guaranteed to be within a valid range of color values regardless of the validity of the weighting transfer functions. This isolates subsequent compositor components and the Profile Connection Space Transform from overflow errors.

~~FF.3~~ FF.2.4 Additional Volumetric Considerations

~~FF.3.1~~ FF.2.4.1 Annotations in Volumetric Presentations States

The Volumetric Presentation States provide two ways for annotating views:

- Annotations on the Volumetric Presentation View

- Annotations described by coordinates in the Volumetric Presentation State Reference Coordinate System (VPS-RCS) with optional references to Structured Reports providing context.

Annotations on the view provide the application of free unformatted text or vector graphics as described in the Section C.10.5 “Graphic Annotation Module” in PS3.3. Since the Graphic Annotation Module allows only the addition of graphics to the 2D view defined by the Presentation State without attached clinical meaning, Volumetric Graphic Annotations provide a mechanism to create annotations in the VPS-RCS with optional references to other objects which can have structured context attached.

Volumetric Graphic Annotations can be specified in two variants: either via Graphic Types with 3D coordinates, as defined in Section C.18.9.1.2 “Graphic Type” in PS3.3, or via a reference to inputs of the Presentation State. The latter is intended to be used to display annotation labels for segmentations of the volume data set; for example, when a lesion has been marked via a Segmentation IOD and this segmentation is rendered together with the anatomical data.

Since annotations which are added via the Graphic Annotation Module are defined within the display space, they should not be used to point to clinical relevant structures which would be positioned on a different anatomy after manipulation.

In contrast since Volumetric Graphic Annotations have coordinates in the VPS-RCS, applications can still show them after a user has manipulated the initial view which has been defined by the Presentation State.

The exact visual representation of the annotations is at the discretion of the display application, as well as the mechanisms which may be employed to ensure that Volumetric Graphic Annotations are sufficiently visible, even if the location in the volume is not visible in the current view. E.g. for a Graphic Type POINT a display application might render a crosshair at the specified position in the volume or a sphere with an arrow pointing to it instead of rendering Volumetric Graphic Annotations directly within the volume a projection of the annotations may be rendered as an overlay on top of the view.

However, annotations can be grouped into ~~Graphics~~ **Graphic** Layers and it is suggested that applications provide mechanisms to define rendering styles per ~~Graphics~~ **Graphic** Layer.

See Section XXX.3.4 “Replacing Set of Derived Images With Single VPS Using Crosscurve Animation” in PS3.17 and Section XXX.3.5 “Volumetric Annotations (example: Trajectory Planning)” in PS3.17 for examples of Volumetric Graphic Annotations.

~~FF.3.2~~ FF.2.4.2 Volumetric Animation

Several different styles of animation are defined in Volumetric Presentation States. In general, an animation style will vary either the input, processing, or view geometry in order to produce a varying presentation view. This section describes each of the animation styles and how it produces an animated view.

~~FF.3.2.1~~ FF.2.4.2.1 Input Sequence Animation

A Presentation Animation Style (0070,1A01) value of INPUT_SEQ indicates that Input Sequence Animation is being specified. In this animation style, a single Volumetric Presentation State is defined which includes input items in the Volumetric Presentation State Input Sequence (0070,1201) with different values of Input Sequence Position Index (0070,1203). The animated presentation view is produced by sequencing through values of Input Sequence Position Index (0070,1203) at a specified animation rate **Recommended** Animation Rate (0070,1A03), where each value of the index produces one 'frame' of the animated view from inputs that have that value of Input Sequence Position Index (0070,1203). See Figure FF.3.2-1.

Note

For example, a set of inputs could be temporally related volumes of a moving anatomical structure like the heart.

There may be more than one input item in Volumetric Presentation State Input Sequence (0070,1201) with the same value of Input Sequence Position Index (0070,1203), in which case the inputs are processed together to produce the frame of the animated view.

Note

For example, pairs of input items could represent the same volume input at a point in time with two different segmentation croppings (representing different organ structures) that are blended together into a single view.

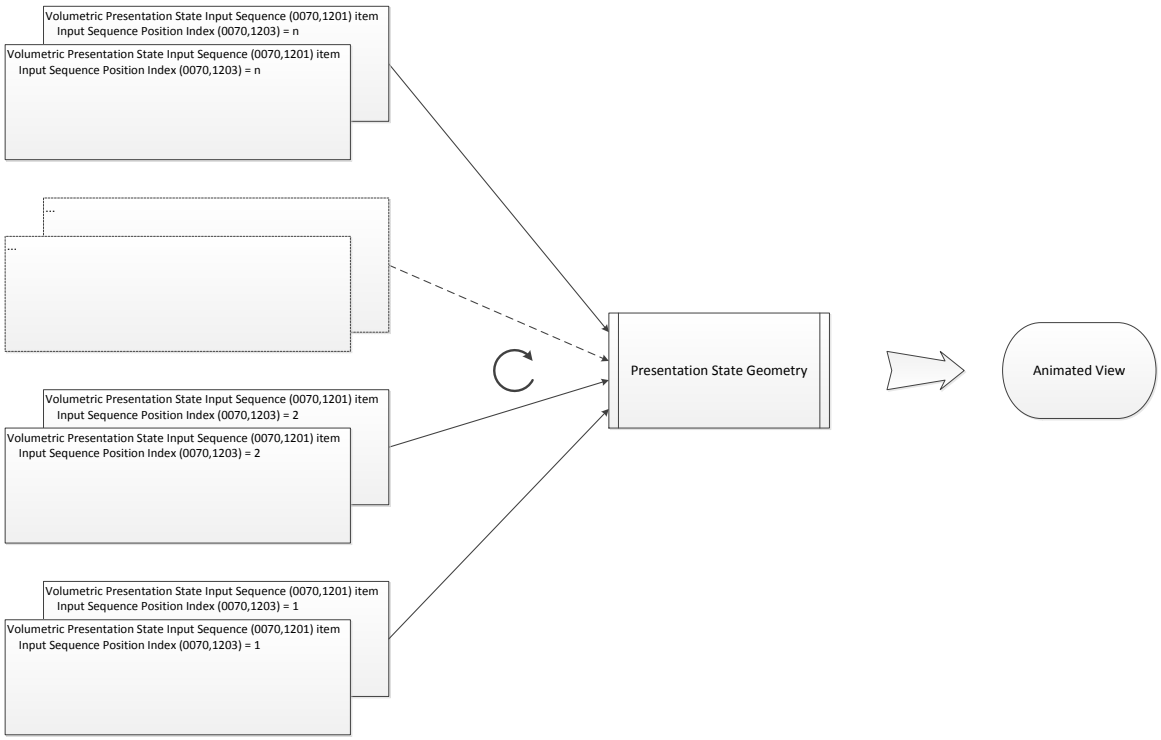

Figure FF.3.2-1. Input Sequence Animation

~~FF.3.2.2~~ FF.2.4.2.2 Presentation Sequence Animation

A Presentation Animation Style (0070,1A01) value of PRESENTATION_SEQ indicates that Presentation Sequence Animation is being specified. In this animation style, a set of Volumetric Presentation States are applied sequentially. See Figure FF.3.2-2.

Note

One example of the use of presentation sequence animation is a view of a moving heart wherein a stent is at a stationary position at the center of the view. Because the geometry of each view frame is slightly different, separate Volumetric Presentation State instances are required for each view frame.

Each Volumetric Presentation State of the set is identified by having the same value of Presentation Sequence Collection UID (0070,1102). The order of application of these Presentation States is determined by the value of Presentation Sequence Position Index (0070,1103) defined in the Presentation State. The animated presentation view is produced by sequencing through values of presentation sequence position index at a specified animation rate **Recommended** Animation Rate (0070,1A03), where each value of the index produces one 'frame' of the animated view produced by that Volumetric Presentation State.

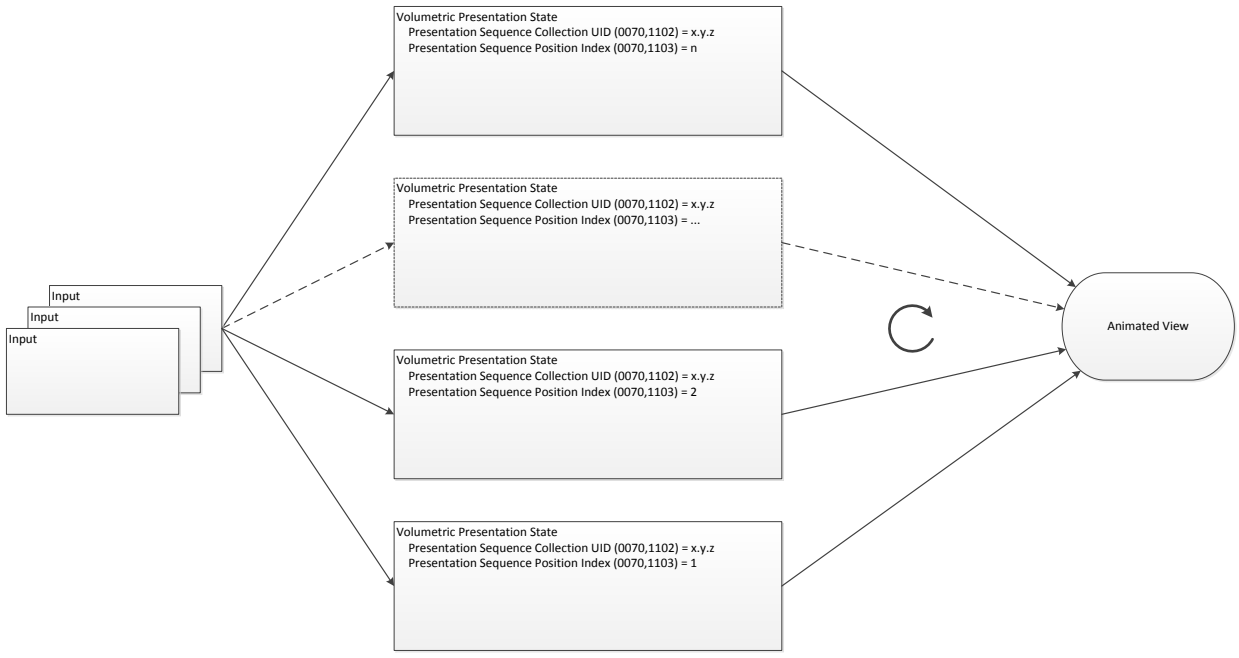

Figure FF.3.2-2. Presentation Sequence Animation

~~FF.3.2.3~~ FF.2.4.2.3 Crosscurve Animation

A Presentation Animation Style (0070,1A01) value of CROSSCURVE indicates that Crosscurve Animation is being specified.

In this animation style, a Presentation State defines a Planar MPR view at the beginning of a curve defined in Animation Curve Sequence (0070,1A04). The Planar MPR view is stepped a distance Animation Step Size (0070,1A05) along the curve defined in Animation Curve Sequence (0070,1A04) at the rate specified by Recommended Animation Rate (0070,1A03) in steps per second. See Figure FF.3.2-3.

Note

A typical application of this animation style is motion along a curve centered within the colon or a blood vessel.

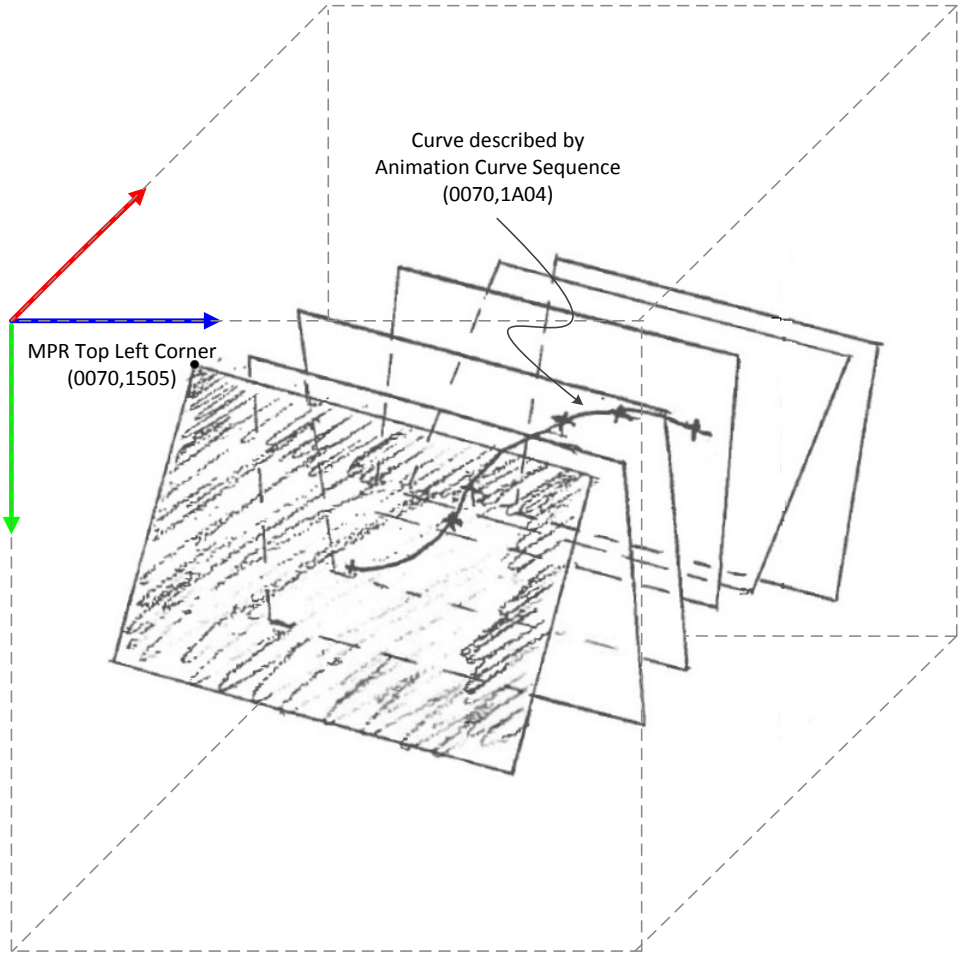

Figure FF.3.2-3. Crosscurve Animation

920 **FF.2.4.2.4 Flythrough Animation**

A Presentation Animation Style (0070,1A01) value of FLYTHROUGH indicates that Flythrough Animation is being specified. In this animation style, the Volumetric Presentation State defines an initial volume rendered view and a specified movement of the view along a path through the volume. See Figure FF.3.2-4.

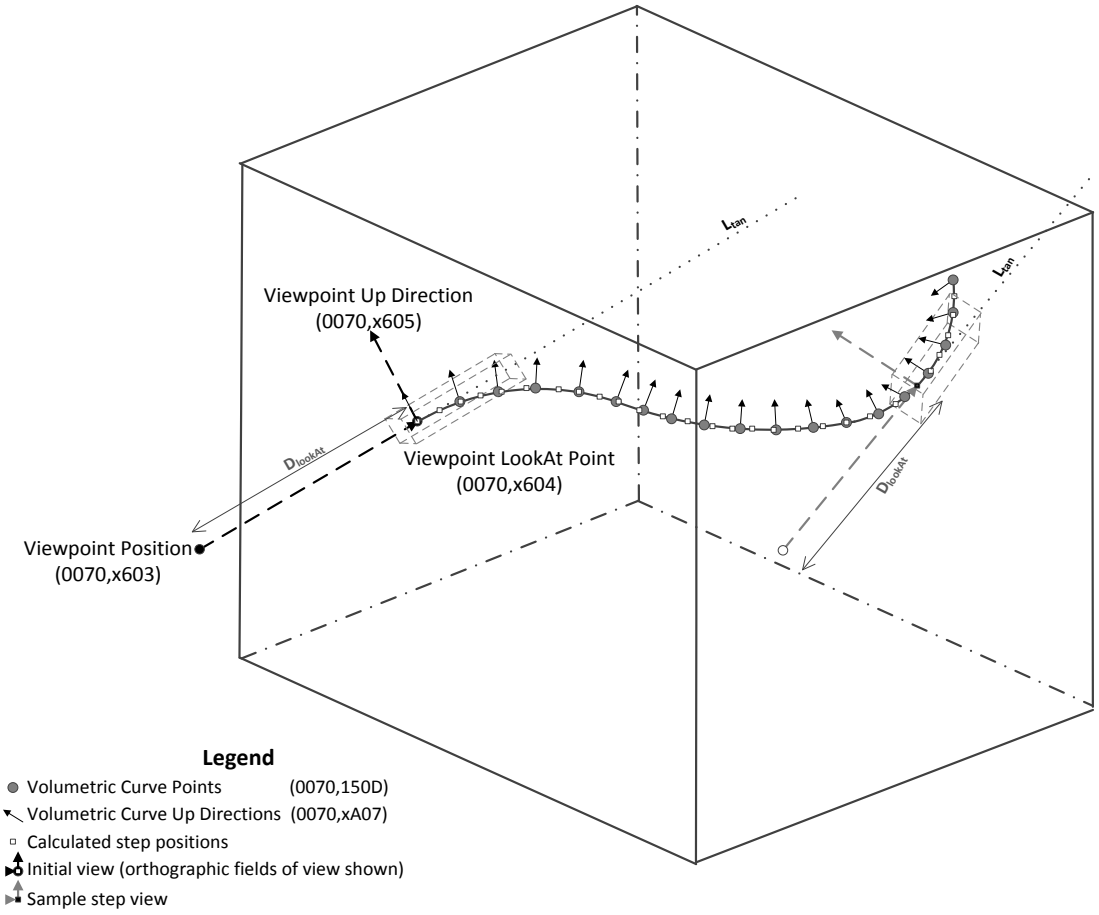

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Figure FF.3.2-4. Flythrough Animation

FF.2.4.2.5 Swivel Animation

A Presentation Animation Style (0070,1A01) value of SWIVEL indicates that Swivel Animation is being specified. In this animation style, a Presentation State defines an initial volume rendered using Viewpoint Position (0070,1603), Viewpoint LookAt Point (0070,1604), and Viewpoint Up Direction (0070,1605). When the animation begins, the view begins to rotate back and forth about an axis parallel to the Viewpoint Up Direction (0070,1605) that intersects the Viewpoint LookAt Point (0070,1604). The extent of the arc of rotation is defined by Swivel Range (0070,1A06) and the maximum rate of rotation is specified by Recommended Animation Rate (0070,1A03) in degrees per second, although it is recommended that the changes of direction at the ends of the swivel range be smooth which implies a slowing of the rotation as the endpoints are approached.

~~FF.3.3~~ FF.2.5 Display Layout

The layout of multiple Volumetric Presentation States is not specified by the ~~Planar MPR~~ Volumetric Transformation ~~Process~~ process. However, there are attributes within Volumetric Presentation States that can influence the overall display layout.

For instance:

- Anatomic Region Sequence (0008,2218) specifies the anatomic region covered by the Volumetric Presentation State
- View Code Sequence (0054,0220) describes the view of the anatomic region of interest (e.g. Coronal, Oblique transverse, etc.)
- Presentation Display Collection UID (0070,1101) identifies the Presentation State as one of a set of views intended to be displayed together
- SOP Class UID (0008,0016) identifies that the Presentation State describes **~~a Planar MPR~~** **the volumetric** view

The use of these attributes allows a display application to create an appropriate presentation of multiple Volumetric Presentation States, whether through the application of a Hanging Protocol instance, a Structured Display instance or by means of an application-specific algorithm.

For an example of their use, see Annex XXX "Volumetric Presentation States (Informative)" in PS3.17.

~~FF.4~~ FF.3 Behavior of An SCP

In addition to the behavior for the Storage Service Class specified in Section B.2.2 "Behavior of an SCP", the following additional requirements are specified for the Volumetric Presentation State Storage SOP Classes:

- a display device acting as an SCP of these SOP Classes shall make all mandatory presentation attributes available for application to the referenced volumetric data at the discretion of the display device user, for all Image Storage SOP Classes defined in the Conformance Statement for which the Volumetric Presentation State Storage SOP Class is supported.
- a display device acting as an SCP of the Volumetric Presentation State Storage SOP Classes shall support the Segmentation SOP Class for cropping and the Spatial Registration SOP Class for registration.
- **a display device acting as an SCP of a Volume Rendering Volumetric Presentation State Storage SOP Class shall perform an unshaded volume rendering if the Render Shading Module is absent from the SOP Instance.**
- a display device acting as an SCP of the Volumetric Presentation State Storage SOP Classes is not required to support the Presentation Animation Module.
- a display device acting as an SCP of any of the Volumetric Presentation State Storage SOP Classes is not required to support Structured Reporting Storage SOP Classes.

~~FF.5~~ FF.4 Conformance

In addition to the Conformance Statement requirements for the Storage Service Class specified in Section B.4.3 "Conformance Statement Requirements", the following additional requirements are specified for the Volumetric Presentation State Storage SOP Classes:

~~FF.5.1~~ FF.4.1 Conformance Statement For An SCU

The following behavior shall be documented in the Conformance Statement of any implementation claiming conformance to a Volumetric Presentation State Storage SOP Class as an SCU:

- For an SCU of a Volumetric Presentation State Storage SOP Class that is creating a SOP Instance of the Class, the manner in which presentation related attributes are derived from a displayed image, operator intervention or defaults, and how they are included in the IOD.

- For an SCU of a Volumetric Presentation State Storage SOP Class, the Image Storage SOP Classes that are also supported by the SCU and which may be referenced by instances of the Volumetric Presentation State Storage SOP Class.

~~FF.5.2~~ FF.4.2 Conformance Statement For An SCP

The following behavior shall be documented in the Conformance Statement of any implementation claiming conformance to a Volumetric Presentation State Storage SOP Class as an SCP:

- For an SCP of a Volumetric Presentation State Storage SOP Class that is displaying an image referred to by a SOP Instance of the Class, the manner in which presentation related attributes are used to influence the display of an image.
- For an SCP of a Volumetric Presentation State Storage SOP Class, the Image Storage SOP Classes that are also supported by the SCP and which may be referenced by instances of the Volumetric Presentation State Storage SOP Class.
- For an SCP of a Volumetric Presentation State Storage SOP Class, whether the Presentation Animation Module is supported, and if not supported, any notifications or lack of notifications to the user that the context information is not displayed.
- For an SCP of a Volumetric Presentation State Storage SOP Class, whether references to Structured Report instances are supported, and if not supported, any notifications or lack of notifications to the user that the context information is not displayed.

Changes to NEMA Standards Publication PS3.6-2016e
Digital Imaging and Communications in Medicine (DICOM)
Part 6: Data Dictionary

Item #11: Add the following rows to PS3.6 Section 6

6 Registry of DICOM data elements

Note: For attributes that were present in ACR-NEMA 1.0 and 2.0 and that have been retired, the specifications of Value Representation and Value Multiplicity provided are recommendations for the purpose of interpreting their values in objects created in accordance with earlier versions of this standard. These recommendations are suggested as most appropriate for a particular attribute; however, there is no guarantee that historical objects will not violate some requirements or specified VR and/or VM.

Tag	Name	Keyword	VR	VM	
(0070,1206)	*Compositing Method*	*CompositingMethod*	*CS*	*1*	RET
(0070,1209)	Volumetric Presentation Input Set UID	VolumetricPresentationInputSetUID	UI	1	
(0070,120A)	Volumetric Presentation Input Set Sequence	VolumetricPresentationInputSetSequence	SQ	1	
(0070,120B)	Global Crop	GlobalCrop	CS	1	
(0070,120C)	Global Cropping Specification Index	GlobalCroppingSpecificationIndex	US	1-n	
(0070,120D)	Rendering Method	RenderingMethod	CS	1	
(0070,1602)	Render Projection	RenderProjection	CS	1	
(0070,1603)	Viewpoint Position	ViewpointPosition	FD	3	
(0070,1604)	Viewpoint LookAt Point	ViewpointLookAtPoint	FD	3	
(0070,1605)	Viewpoint Up Direction	ViewpointUpDirection	FD	3	
(0070,1606)	Render Field of View	RenderFieldOfView	FD	6	
(0070,1607)	Sampling Step Size	SamplingStepSize	FD	1	
(0070,1701)	Shading Style	ShadingStyle	CS	1	
(0070,1702)	Ambient Reflection Intensity	AmbientReflectionIntensity	FD	1	
(0070,1703)	Light Direction	LightDirection	FD	3	
(0070,1704)	Diffuse Reflection Intensity	DiffuseReflectionIntensity	FD	1	
(0070,1705)	Specular Reflection Intensity	SpecularReflectionIntensity	FD	1	
(0070,1706)	Shininess	Shininess	FD	1	
(0070,1A06)	Swivel Range	SwivelRange	FD	1	
(0070,1A07)	Volumetric Curve Up Directions	VolumetricCurveUpDirections	OD	1	
(0070,1A08)	Volume Stream Sequence	VolumeStreamSequence	SQ	1	
(0070,1A09)	RGBA Transfer Function Description	RGBATransferFunctionDescription	LO	1	

Item #12: Add the following rows to PS3.6 Annex A Table A-1

UID Value	UID Name	UID Type	Part
1.2.840.10008.5.1.4.1.1.11.9	Volume Rendering Volumetric Presentation State Storage	SOP Class	PS3.4
1.2.840.10008.5.1.4.1.1.11.10	Segmented Volume Rendering Volumetric Presentation State Storage	SOP Class	PS3.4
1.2.840.10008.5.1.4.1.1.11.11	Multiple Volume Rendering Volumetric Presentation State Storage	SOP Class	PS3.4

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Changes to NEMA Standards Publication PS3.17-2016e
Digital Imaging and Communications in Medicine (DICOM)
Part 17: Explanatory Information

Item #13: Append to PS3.17 Section XXX

XXX.3 Use Cases

XXX.3.10 Highlighting Areas of Interest in Volume Rendered View

XXX.3.10.1 User Scenario

The goal is the Identification and Annotation of a bilateral iliac stenosis with an acquired CT scan. The objective is the visualization of a leg artery with a three-dimensional annotation. There are also informative two-dimensional annotations.

XXX.3.10.2 Encoding Outline

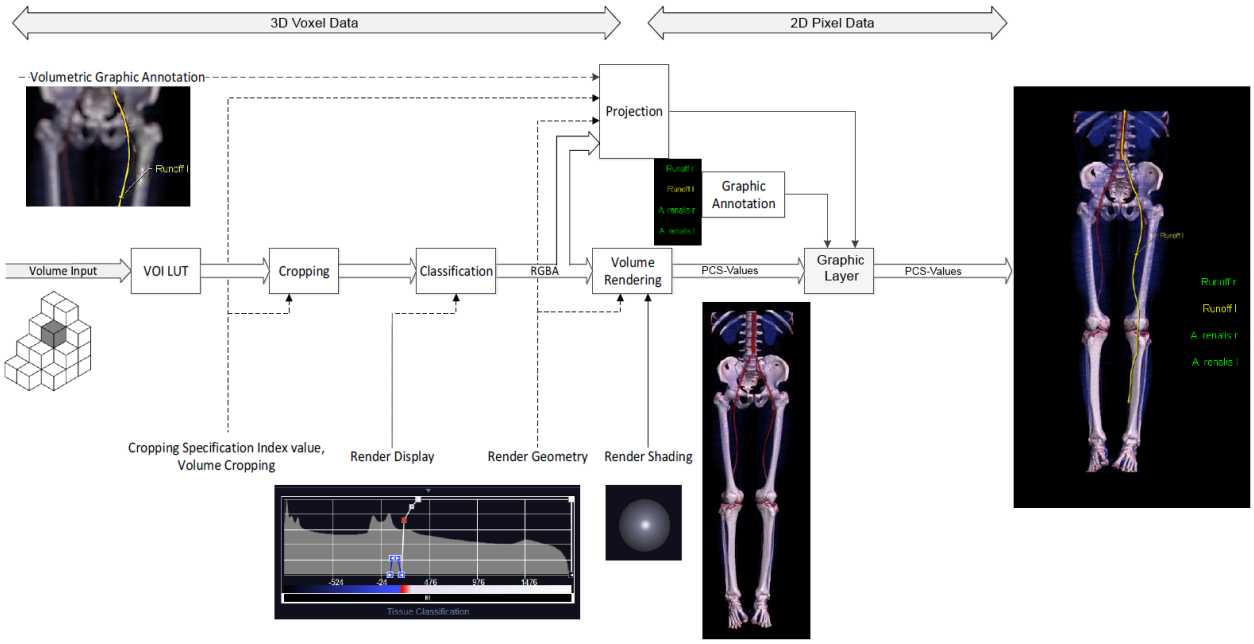

Figure XXX.3.10-1: Highlighted Areas of Interest Volume Rendered View Pipeline

Specifying the classification transfer function, it is possible to provide a color and adjust the opacity of the rendering of different Hounsfield Units. The Render Shading Module is used to adjust parameters like the shininess and the different reflections. The Volumetric Graphic Annotation is used to display the active vessel selection. The Volumetric Graphic Annotation is a projection in the 3D Voxel Data, while the Graphic Annotation module provides annotation made directly in the 2D pixel data. Both types of annotation specify a Graphic Layer in which the annotation is displayed.

XXX.3.10.3 Encoding Details

XXX.3.10.3.1 Volume Presentation State Relationship Module Recommendations

Attribute Name	Tag	Comment
Volumetric Presentation Input Set Sequence	(0070,120A)	
ITEM #1		

>Volumetric Presentation Input Set UID	(0070,1209)	Set to *UID1*
>Presentation Input Type	(0070,1202)	Set to VOLUME
>Referenced Image Sequence	(0008,1140)	Reference to CT volume
Volumetric Presentation State Input Sequence	(0070,1201)	
ITEM #1		
>Volumetric Presentation Input Number	(0070,1207)	Set to 1
>Volumetric Presentation Input Set UID	(0070,1209)	Set to *UID1*, referencing the first item in the Volumetric Presentation Input Set Sequence (0070,120A)
>Include VOI LUT Macro Table C.11-2B		Set to identity
>Crop	(0070,1204)	Set to NO

XXX.3.10.3.2 Volume Render Geometry Module Recommendations

Attribute Name	Tag	Comment
Render Projection	(0070,1602)	Set to “ORTHOGRAPHIC”
Viewpoint Position	(0070,1603)	Defines the viewpoint specifying a standard anterior coronal view.
Viewpoint Look At Point	(0070,1604)	
Viewpoint Up Direction	(0070,1605)	
Render Field of View	(0070,1606)	Defines a field of view that covers the entire range of the scan.
Rendering Method	(0070,120D)	Set to “VOLUME_RENDERED”

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XXX.3.10.3.3 Render Shading Module Recommendations

Attribute Name	Tag	Comment
Shading Style	(0070,1701)	Set to “DOUBLESIDED”
Ambient Reflection Intensity	(0070,1702)	Set to 0.5
Light Direction	(0070,1703)	Set to (0.0, 0.0, -1.0)
Diffuse Reflection Intensity	(0070,1704)	Set to 0.5
Specular Reflection Intensity	(0070,1705)	Set to 0.5
Shininess	(0070,1706)	Set to 0.2

XXX.3.10.3.4 Render Display Module Recommendations

Attribute Name	Tag	Comment
Pixel Presentation	(0008,9205)	Set to “TRUE_COLOR”

Volume Stream Sequence	(0070,1A08)	
ITEM#1 of Volume Stream Sequence		
>Volumetric Presentation Input Set UID	(0070,1209)	Set to *UID1*, referencing the first item in the Volumetric Presentation Input Set Sequence (0070,120A)
>Presentation State Classification Component Sequence	(0070,1801)	
>ITEM#1 of Presentation State Classification Component Sequence		
>>Component Type	(0070,1802)	Set to ONE_TO_RGBA
>>Component Input Sequence	(0070,1803)	
>>ITEM#1 of Component Input Sequence		
>>>Volumetric Presentation Input Index	(0070,1804)	Set to 1 referencing the first item in Volumetric Presentation State Input Sequence (0070,1201)
>>RGB LUT Transfer Function	(0028,140F)	Set to TABLE
>>Alpha LUT Transfer Function	(0028,1410)	Set to TABLE
>> RGB *Palette Color Lookup Table Descriptors and Data*		
>> Alpha *Palette Color Lookup Table Descriptor and Data*		
Presentation State Compositor Component Sequence	(0070,1805)	*empty*
ICC Profile	(0028,2000)	Value corresponding to IEC 61966-2-1:1999
Color Space	(0028,2002)	Set to SRGB

1050 **XXX.3.10.3.5 Volumetric Graphic Annotation Module Recommendations**

Attribute Name	Tag	Comment
Volumetric Annotation Sequence	(0070,1901)	
ITEM#1		
>Graphic Data	(0070,0022)	Set to a sequence of (x,y,z) points that follow the right femoral artery
>Graphic Type	(0070,0023)	Set to MULTIPOINT
>Graphic Layer	(0070,0002)	Set to 1
>Annotation Clipping	(0070,1907)	Set to NO
>Text Object Sequence	(0070,0008)	
>>Unformatted Text Value	(0070,0006)	Set to “Runoff”

XXX.3.10.3.6 Graphic Layer Module Recommendations

Attribute Name	Tag	Comment
Graphic Layer Sequence	(0070,0060)	

>Graphic Layer	(0070,0002)	Set to “Runoff R”
>Graphic Layer Order	(0070,0062)	Set to 1

XXX.3.11 Colorized Volume Rendering of Segmented Volume Data

XXX.3.11.1 User Scenario

A tumor in a volume has been identified and segmented. In volume rendered views the tumor is highlighted while preserving information about its relationship to surrounding anatomy.

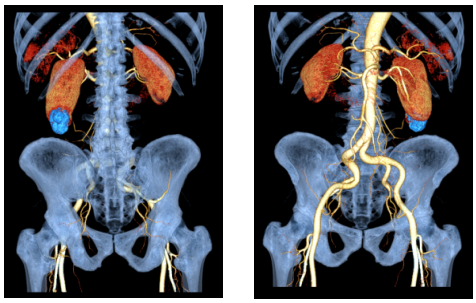

Figure XXX.3.11-1: Colorized Volume Rendering of Segmented Volume Data Pipeline

XXX.3.11.2 Encoding Outline

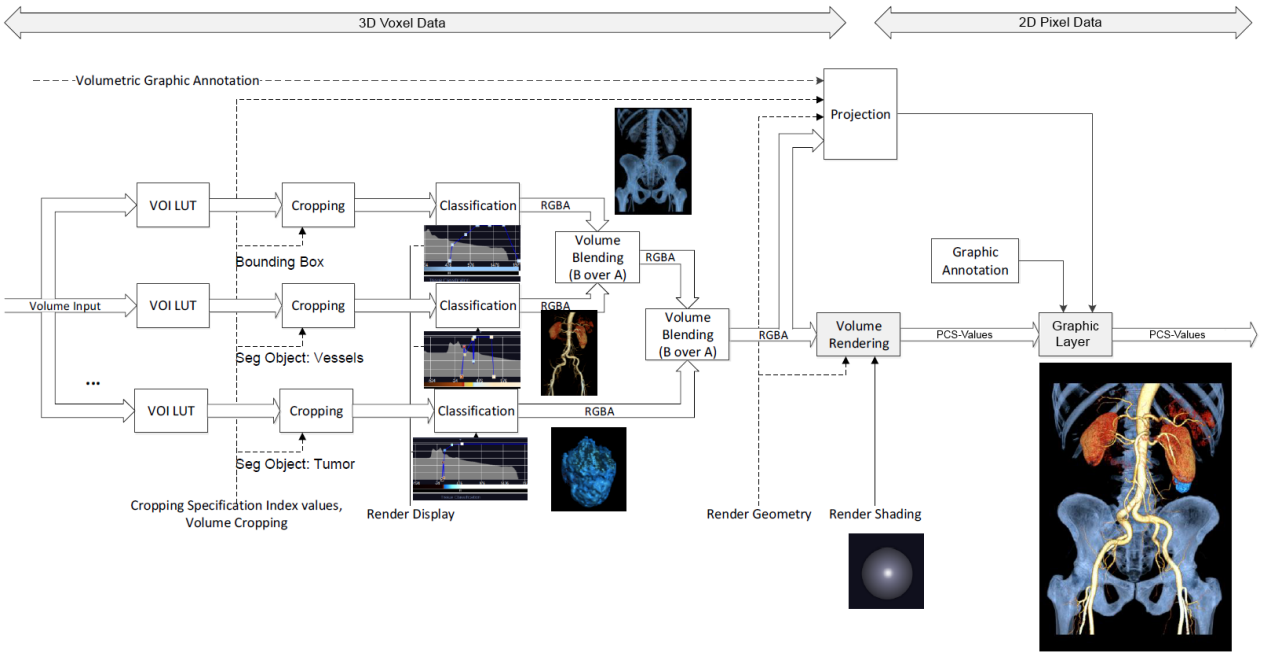

Figure XXX.3.11-2: Segmented Volume Rendering Pipeline

In this pipeline the different classifications for the segmented objects are shown, followed by the blending operations. To visualize the vessels, they are first classified with a special transfer function and then blended over the background image. The segmented Tumor is also classified and then blended over the Vessels +

Bones. Generally the classified segmented volumes are blended in lowest to highest priority order using B-over-A blending of the RGB data and the corresponding opacity (alpha) data.

XXX.3.11.3 Encoding Details

XXX.3.11.3.1 Volumetric Presentation State Relationship Module Recommendations

Attribute Name	Tag	Comment
Volumetric Presentation Input Set Sequence	(0070,120A)	One item in this sequence
ITEM #1		
>Volumetric Presentation Input Set UID	(0070,1209)	Set to *UID1*
>Presentation Input Type	(0070,1202)	Set to VOLUME
>Referenced Image Sequence	(0070,1140)	Set reference(s) to the image(s) that make up the input volume
Volumetric Presentation State Input Sequence	(0070, 1201)	Three items are this sequence.
ITEM #1		
>Volumetric Presentation Input Number	(0070,1207)	Set to 1
>Volumetric Presentation Input Set UID	(0070,1209)	Set to *UID1*
>Include VOI LUT Macro Table C.11-2B		Set to identity
>Crop	(0070, 1204)	Set to 'NO'
>ITEM #2		
>Volumetric Presentation Input Number	(0070,1207)	Set to 2
>Volumetric Presentation Input Set UID	(0070,1209)	Set to *UID1*
>Include VOI LUT Macro Table C.11-2B		Set to identity
>Crop	(0070, 1204)	Set to 'NO'
>ITEM #3		
>Volumetric Presentation Input Number	(0070,1207)	Set to 3
>Volumetric Presentation Input Set UID	(0070,1209)	Set to *UID1*
>Include VOI LUT Macro Table C.11-2B		Set to identity
>Crop	(0070, 1204)	Set to 'NO'

XXX.3.11.3.2 Volume Render Geometry Module Recommendations

Attribute Name	Tag	Comment
Render Projection	(0070,1602)	Set to ORTHOGRAPHIC
Viewpoint Position	(0070,1603)	Viewpoint specifies a posterior coronal view
Viewpoint Look At Point	(0070,1604)	
Viewpoint Up Direction	(0070,1605)	
Render Field of View	(0070,1606)	Field of view covers the entire range of the scan.

Rendering Method	(0070,120D)	Set to VOLUME_RENDERED

XXX.3.11.3.3 Render Shading Module Recommendations

Attribute Name	Tag	Comment
Shading Style	(0070,1701)	Set to “DOUBLESIDED”
Ambient Reflection Intensity	(0070,1702)	Set to 0.6
Light Direction	(0070,1703)	Set to (1.0, 0.0, -1.0)
Diffuse Reflection Intensity	(0070,1704)	Set to 0.6
Specular Reflection Intensity	(0070,1705)	Set to 0.4
Shininess	(0070,1706)	Set to 0.3

XXX.3.11.3.4 Render Display Module Recommendations

Attribute Name	Tag	Comment
Pixel Presentation	(0008, 9205)	Set to ‘TRUE_COLOR’
Volume Stream Sequence	(0070,1A08)	One item in this sequence
ITEM #1 in Volume Stream Sequence		
>Volumetric Presentation Input Set UID	(0070,1209)	UID1
>Presentation State Classification Component Sequence	(0070,1801)	Include three items, one for each classification component
>ITEM #1 in Presentation State Classification Component Sequence		
>>Component Type	(0070, 1802)	Set to ‘ONE_TO_RGBA’
>>Component Input Sequence	(0070, 1803)	Set only one item in this sequence, since the component has only one input.
>>ITEM #1 in Component Input Sequence		
>>>Volumetric Presentation Input Index	(0070,1804)	Set to ‘1’ for the bones.
>>RGB LUT Transfer Function	(0028,140F)	Set to ‘TABLE’.
>>Alpha LUT Transfer Function	(0028,1410)	Set to ‘TABLE’.
>> RGB *Palette Color Lookup Table Descriptors and Data*		
>> Alpha *Palette Color Lookup Table Descriptor and Data*		
>ITEM #2 in Presentation State Classification Component Sequence		
>>Component Type	(0070, 1802)	Set to ‘ONE_TO_RGBA’
>>Component Input Sequence	(0070, 1803)	Set only one item in this sequence, since the component has only one input.
>>ITEM #1 in Component Input Sequence		
>>>Volumetric Presentation Input Index	(0070,1804)	Set to ‘2’ for the segmented vessels and kidneys
>>RGB LUT Transfer Function	(0028,140F)	Set to ‘TABLE’
>>Alpha LUT Transfer Function	(0028,1410)	Set to ‘TABLE’.
>> RGB *Palette Color Lookup Table Descriptors and Data*		
>> Alpha *Palette Color Lookup Table Descriptor and Data*		

>ITEM #3 in Presentation State Classification Component Sequence		
>>Component Type	(0070, 1802)	Set to ‘ONE_TO_RGBA’
>>Component Input Sequence	(0070, 1803)	Set only one item in this sequence, since the component has only one input.
>>ITEM #1 in Component Input Sequence		
>>Volumetric Presentation Input Index	(0070,1804)	Set to ‘3’ for the segmented tumor.
>RGB LUT Transfer Function	(0028,140F)	Set to ‘EQUAL_RGB’
>Alpha LUT Transfer Function	(0028,1410)	Set to “NONE”.
Presentation State Compositor Component Sequence	(0070,1805)	*empty*
ICC Profile	(0028,2000)	Value corresponding to IEC 61966-2-1:1999
Color Space	(0028,2002)	Set to SRGB

XXX.3.12 Liver Resection Planning

XXX.3.12.1 User Scenario

A patient has been imaged by CT at arterial and portal venous contrast phases in order to plan for a liver resection. The two phases are rendered together to visualize the relationship of the tumor to the portal vein, hepatic veins and hepatic arteries to ensure the resection avoids these structures.

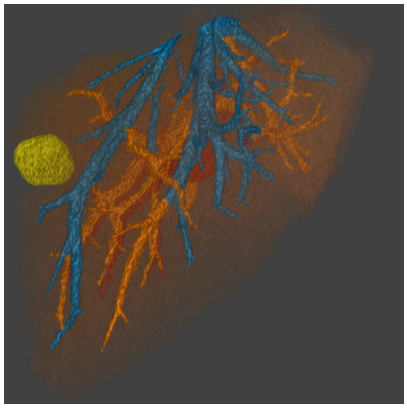

Figure XXX.3.12-1: Liver Resection Planning Pipeline

XXX.3.12.2 Encoding Outline

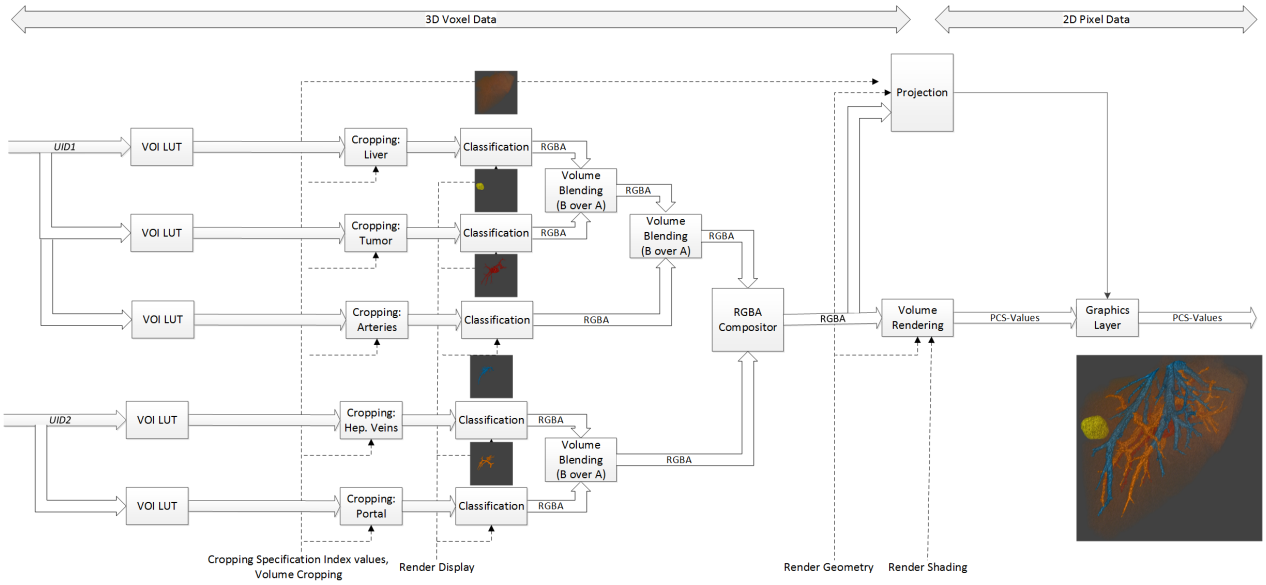

Figure XXX.3.12-2: Multiple Volume Rendering Pipeline

In this pipeline, volume streams from two volume inputs are blended together. From the arterial phase volume input, segmented views of the liver, tumor and hepatic arteries are blended in sequence (B over A). From the venous phase volume input, segmented views of the hepatic veins and the portal vein are blended in sequence (B over A). Outputs from these operations are blended together with both given equal weight.

XXX.3.12.3 Encoding Details

XXX.3.12.3.1 Volumetric Presentation State Relatonship Module Recommendations

Attribute Name	Tag	Comment
Volumetric Presentation Input Set Sequence	(0070,120A)	
#ITEM 1		
>Volumetric Presentation Input Set UID	(0070,1209)	Set to *UID1*
>Presentation Input Type	(0070,1202)	Set to VOLUME
>Referenced Image Sequence	(0008,1140)	Reference to Arterial phase CT volume
#ITEM2		
>Volumetric Presentation Input Set UID	(0070,1209)	Set to *UID2*
>Presentation Input Type	(0070,1202)	Set to VOLUME
>Referenced Image Sequence	(0008,1140)	Reference to Portal Venous phase CT volume
Volumetric Presentation State Input Sequence	(0070,1201)	
#ITEM1		
>Volumetric Presentation Input Number	(0070,1207)	Set to 1
>Volumetric Presentation Input Set UID	(0070,1209)	Set to *UID1*
>Include VOI LUT Macro Table C.11-2B		Set to identity
>Crop	(0070,1204)	Set to YES
>Cropping Specification Index	(0070,1205)	Set to 1
#ITEM2		
>Volumetric Presentation Input Number	(0070,1207)	Set to 2
>Volumetric Presentation Input Set UID	(0070,1209)	Set to *UID1*
>Include VOI LUT Macro Table C.11-2B		Set to identity
>Crop	(0070,1204)	Set to YES
>Cropping Specification Index	(0070,1205)	Set to 2
#ITEM3		
>Volumetric Presentation Input Number	(0070,1207)	Set to 3

>Volumetric Presentation Input Set UID	(0070,1209)	Set to *UID1*
>Include VOI LUT Macro Table C.11-2B		Set to identity
>Crop	(0070,1204)	Set to YES
>Cropping Specification Index	(0070,1205)	Set to 3
#ITEM4		
>Volumetric Presentation Input Number	(0070,1207)	Set to 4
>Volumetric Presentation Input Set UID	(0070,1209)	Set to *UID2*
>Include VOI LUT Macro Table C.11-2B		Set to identity
>Crop	(0070,1204)	Set to YES
>Cropping Specification Index	(0070,1205)	Set to 4
#ITEM5		
>Volumetric Presentation Input Number	(0070,1207)	Set to 5
>Volumetric Presentation Input Set UID	(0070,1209)	Set to *UID2*
>Include VOI LUT Macro Table C.11-2B		Set to identity
>Crop	(0070,1204)	Set to YES
>Cropping Specification Index	(0070,1205)	Set to 5

XXX.3.12.3.2 Volume Cropping Module Recommendations

Attribute Name	**Tag**	**Comment**
Volume Cropping Sequence	(0070,1301)	
#ITEM1		
>Cropping Specification Number	(0070,1309)	Set to 1
>Volume Cropping Method	(0070,1302)	Set to INCLUDE_SEG
>Referenced Image Sequence	(0008,1140)	Reference to Liver segment
#ITEM2		
>Cropping Specification Number	(0070,1309)	Set to 2
>Volume Cropping Method	(0070,1302)	Set to INCLUDE_SEG
>Referenced Image Sequence	(0008,1140)	Reference to Tumor segment
#ITEM3		

>Cropping Specification Number	(0070,1309)	Set to 3
>Volume Cropping Method	(0070,1302)	Set to INCLUDE_SEG
>Referenced Image Sequence	(0008,1140)	Reference to Hepatic arteries segment
#ITEM4		
>Cropping Specification Number	(0070,1309)	Set to 4
>Volume Cropping Method	(0070,1302)	Set to INCLUDE_SEG
>Referenced Image Sequence	(0008,1140)	Reference to Hepatic veins segment
#ITEM5		
>Cropping Specification Number	(0070,1309)	Set to 5
>Volume Cropping Method	(0070,1302)	Set to INCLUDE_SEG
>Referenced Image Sequence	(0008,1140)	Reference to Portal vein segment

XXX.3.12.3.3 Volume Render Geometry Module Recommendations

Attribute Name	Tag	Comment
Render Projection	(0070,1602)	Set to ORTHOGRAPHIC
Viewpoint Position	(0070,1603)	Viewpoint specifies an oblique right-anterior view
Viewpoint Look At Point	(0070,1604)	
Viewpoint Up Direction	(0070,1605)	
Render Field of View	(0070,1606)	Field of view covers the entire range of the scan.
Rendering Method	(0070,120D)	Set to VOLUME_RENDERED

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XXX.3.12.3.4 Render Shading Module Recommendations

Attribute Name	Tag	Comment
Shading Style	(0070,1701)	Set to DOUBLESIDED
Ambient Reflection Intensity	(0070,1702)	Set to 0.1

XXX.3.12.3.5 Render Display Module Recommendations

Attribute Name	Tag	Comment
Pixel Presentation	(0008,9205)	Set to TRUE_COLOR
Volume Stream Sequence	(0070,1A08)	

#ITEM1 of Volume Stream Sequence		
>Volumetric Presentation Input Set UID	(0070,1209)	Set to *UID1*
>Presentation State Classification Component Sequence	(0070,1801)	
>#ITEM1 of Presentation State Classification Component Sequence		
>>RGBA Transfer Function Description	(0070,1A09)	Set to “Liver, semi-opaque”
>>Component Type	(0070,1802)	Set to ONE_TO_RGBA
>>Component Input Sequence	(0070,1803)	
>>> Volumetric Presentation Input Index	(0070,1804)	Set to 1
>>RGB LUT Transfer Function	(0028,140F)	TABLE
>>Alpha LUT Transfer Function	(0028,1410)	TABLE
>>*Red, Green, Blue Palette Color Lookup Table Descriptors and Data*		Orange tint
>>*Alpha Palette Color Lookup Table Descriptor and Data*		Semi-transparent across liver H.U.range
>#ITEM2 of Presentation State Classification Component Sequence		
>>RGBA Transfer Function Description	(0070,1A09)	Set to “Tumor mass, solid”
>>Component Type	(0070,1802)	Set to ONE_TO_RGBA
>>Component Input Sequence	(0070,1803)	
>>> Volumetric Presentation Input Index	(0070,1804)	Set to 2
>>RGB LUT Transfer Function	(0028,140F)	TABLE
>>Alpha LUT Transfer Function	(0028,1410)	NONE
>>*Red, Green, Blue Palette Color Lookup Table Descriptors and Data*		Yellow tints
>#ITEM3 of Presentation State Classification Component Sequence		
>>RGBA Transfer Function Description	(0070,1A09)	Set to “Contrast-enhanced vessels, red”
>>Component Type	(0070,1802)	Set to ONE_TO_RGBA
>>Component Input Sequence	(0070,1803)	
>>> Volumetric Presentation Input Index	(0070,1804)	Set to 3
>>RGB LUT Transfer Function	(0028,140F)	TABLE
>>Alpha LUT Transfer Function	(0028,1410)	NONE
>>*Red, Green, Blue Palette Color Lookup Table Descriptors and Data*		Red tints
#ITEM2 of Volume Stream Sequence		
>Volumetric Presentation Input Set UID	(0070,1209)	Set to *UID2*
>Presentation State Classification Component Sequence	(0070,1801)	
>#ITEM1 of Presentation State Classification Component Sequence		

>>RGBA Transfer Function Description	(0070,1A09)	Set to “Contrast-enhanced vessels, blue”
>>Component Type	(0070,1802)	Set to ONE_TO_RGBA
>>Component Input Sequence	(0070,1803)	
>>> Volumetric Presentation Input Index	(0070,1804)	Set to 4
>>RGB LUT Transfer Function	(0028,140F)	TABLE
>>Alpha LUT Transfer Function	(0028,1410)	NONE
>>Red, Green, Blue Palette Color Lookup Table Descriptors and Data		Blue tints
>#ITEM2 of Presentation State Classification Component Sequence		
>>RGBA Transfer Function Description	(0070,1A09)	Set to “Contrast-enhanced vessels, orange”
>>Component Type	(0070,1802)	Set to ONE_TO_RGBA
>>Component Input Sequence	(0070,1803)	
>>> Volumetric Presentation Input Index	(0070,1804)	Set to 5
>>RGB LUT Transfer Function	(0028,140F)	TABLE
>>Alpha LUT Transfer Function	(0028,1410)	NONE
>>Red, Green, Blue Palette Color Lookup Table Descriptors and Data		Orange tints
Presentation State Compositor Component Sequence	(0070,1805)	
#ITEM1		
>Weighting Transfer Function Sequence	(0070,1806)	Specify tables that give equal weight to both volumes
ICC Profile	(0028,2000)	Value corresponding to IEC 61966-2-1:1999
Color Space	(0028,2002)	Set to SRGB

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