Digital Imaging and Communications in Medicine (DICOM)

Supplement 228: Web Services for Volumetric Rendering

Prepared by:

DICOM Standards Committee, Working Group 27: Web Technologies

1300 N. 17th Street, Suite 900

Rosslyn, Virginia 22209 USA

Status: Letter Ballot, 29 May 2024

Developed pursuant to DICOM Work Item 2020-12-B

Table of Contents

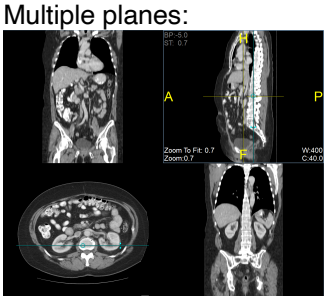
Closed Issues....4
Scope and Field of Application....9
Modifications to PS3.2....9
Modifications to PS3.18....18
8.11 Security and Privacy....26
B.x1 Render a Series as a 3D Volume....33
B.x2 Render a Multi-frame Instance as a 3D Volume Rendering....33
B.x3 Render a Study as an MPR....34
B.x4 Render One Phase of a Multi-phase Series as an MIP....35
X Rendered Volume Response Module....37
X.1 Response Message Body....37
Modifications to PS3.17....38
XXX. Volumetric Rendering ~~Presentation States~~ (Informative)....38
XXX.a Scope of Volumetric Rendering Web Service....38
XXX.a.1 Volumetric Rendering Web Service Examples....38
XXX.a.1.1 MPR Rendering of a CT Series....38
XXX.a.1.1.1 Volumetric Rendering Web Service Pipeline....39
XXX.a.1.2 3D MIP Rendering of an Enhanced MR Instance....40
XXX.a.1.2.1 Volumetric Rendering Web Service Pipeline....41
XXX.b Converting MPR Orientation to Viewpoint Attributes in Volumetric Rendering Web Services....42

1

Closed Issues

1.	How should tradeoffs in quality vs. media size be addressed for lightweight devices? **Response:** Existing quality and scaling parameters.
2.	What is the desired level of “interactivity” for the basic user agent? **Response:** pan, zoom, rotate, animate, windowing, set rendering method
3.	Do we need to support Volume Rendering Protocols that can be applied in Hanging Protocols for a zero-footprint viewer? **Response:** No Public Comment version of this supplement proposed a Volumetric Rendering Protocol IOD, designed to facilitate volumetric rendering by specifying image selection criteria and volumetric rendering parameters. However, discussions within WG-06 and WG-27 revealed challenges in pre-defining image inputs and dynamically resampling Volume Data to accommodate a diverse range of Target Resources. Considering the limited adoption of NPI protocols, WG-27 decided to release the Letter Ballot version without the Protocol IOD. WG-27 plans to revisit the protocol in a separate supplement.
4.	Is there additional support required for Ultrasound? **Response:** No MPR should address most needs.
5.	How is vendor proprietary binary data supported? **Response:** Out of scope.
6.	Should orientation Query Parameters override those in a Volumetric Presentation State? **Response**: Yes See explanation added to PS3.18 Section 8.3.5.3
7.	Should the Volumetric Presentation State UID be required as the Target Resource in all requests? **Response**: No Instances and frames are also allowed as the Target Resource.
8.	Are the “volume” or the “input instances” the Target Resource? **Response**: Input instances. This is consistent with Volumetric Presentation States. “Volume Data” is an element of the rendering pipeline for Volumetric Presentation states and Volumetric Web Services.

9.	Should this service be extended to the URI Web Service PS18 9.x? **Response**: No The Retrieve Transaction of the Studies Web Service is sufficient. Addressing URI would add complexity.
10.	How can the returned media be as predictable as possible for the user agent when the Target Resource is 4D? **Response**: Returned media is based on the Target Resource and accept media type. See examples in this supplement.
11.	Is the proposed text in PS18 8.11 sufficient to address recognizable visual features that could be displayed by volumetric rendering? **Response:** Yes This was deemed sufficient by WG-06 and WG-14.
12.	How should a 4D animation (e.g., of a beating heart) be created? **Response**: See example B.x3. 4D animation is created when the user agent selects temporal input instances and requests a Video media type.
13.	Should multiple blended volumes (e.g., merging CT and PET) be supported? **Response**: No This is out of scope for the basic user agent and addressed by Volumetric Presentation States in the Multiple Volume Rendering Volumetric Presentation State Storage IOD.
14.	Should viewport scaling be allowed as an overriding parameter for Volumetric Presentation States? **Response**: No
15.	Is it appropriate to apply an iccprofile to a color Volume Rendering? **Response**: Yes Color space for the rendered image is not defined by DICOM. ICC Profile parameters may be embedded in compatible media formats returned by the origin server, however due to variation in applications that support ICC profiles, there is no guarantee of a standardized color space for rendered images.
16.	Does multi-planar reformat (MPR) describe one view of a single reformatted plane or multiple synchronized views of multiple planes?

	Single plane:  Multiple planes:  **Response**: The de-facto definition MPR refers to a single plane. This plane can be reconstructed in one of several arbitrary planes. The MPR endpoint returns a single planar reformat. The client may create a display (or hanging protocol) consisting of multiple spatiality related planar reformats. See PS3.17 XXX.3.2.1, which states “Planar MPR views are often displayed together with other spatially related Planar MPR views”.
17.	Should this service be extensible? For example, could an origin server offer parameters to invoke a post processing application, such as automatic bone removal? **Response**: Yes To the extent that is already allowed in PS3.18 Section 8.3, which allows origin servers to define additional Query Parameters.
18.	Should there be an API to save a Volumetric Presentation State? **Response**: No The existing Store Transaction (a.k.a. STOW) is sufficient.
19.	Should 3D and MPR be in the same service, or distinct? This could be useful for conformance. **Response**: 3D and MPR has been separated into two services based on recommendation from WG-06.
20.	Should all camera orientation Query Parameters be required in a request (i.e., “viewpointposition”, “viewpointlookat”, and “viewpointup”), or can one or more be omitted? **Response**: No If camera orientation Query Parameters are absent, the origin server may apply a default value.
21.	Should there be a resource that exposes the organized Volume Data as a bulkdata resource? **Response:** No This could be considered for a future work item if there is interest.

22.	Do User Agents need named oblique planes (e.g., LAO, RAO) to control anatomic orientation? **Response:** No. This supplement does not introduce oblique anatomic planes, as this would introduce a large number of projections, increasing complexity. Perpendicular planes are available in the Orientation parameter (See Section 8.3.5.3.4). User Agents could also use Viewpoint LookAt, Viewpoint position and Viewpoint Up Query Parameters to modify anatomic orientation.
23.	Are there other parameters or options that should be considered for selection of multi-phasic inputs and multi-volume rendering? Examples include: • A Volume Definition Object (similar to KOS)? • A service to identify instances that meet the Volume Input Requirements in section C.11.23.1 of PS3.3? • Let the origin server choose? • Some combination of solutions? **Response:** No This supplement introduces parameters: Volume Input Reference (Section 8.3.5.3.1) and Matching Attributes (Section 8.3.5.3.2).
24.	Are additional animation parameters needed? **Response:** No We considered the use case of rotating a 3D object to create a movie for ppt or multimedia report, however, the Presentation Animation Module may be too complex for some user agents. The following parameters should be adequate: Volumetric Curve Point Coordinates (8.3.5.3.10), Animation Step Size (8.3.5.3.11), and Animation Rate (8.3.5.3.12).
25.	Should Segmentation and 3D print IODs be added to the scope of this supplement? **Response:** No This could be addressed in a future work item. Rendered MPR Volume and Rendered 3D Volume Resources limit the Target Resource to “either a Volumetric Presentation State Instance, or a collection of Image Instances or frames within Image Instances”.

26.	Is using camera parameters instead of direction cosines for MPR orientation OK? **Response:** Yes No public comment was received on this item. In this supplement, camera orientation parameters (i.e., “viewpointposition”, “viewpointlookat”, or “viewpointup”) apply to rendered 3D and MPR. Part 17 content has been added to explain the conversion MPR direction cosines to camera orientation parameters.
27.	Are zoom parameters beyond viewport scaling needed for 3D? **Response:** No No public comment was received on this item. Since the existing viewport scaling can be used for a 2D zoom after a volume is rendered, this supplement does not include Query Parameters corresponding to Render Field of View (0070,1606) or MPR View Width (0070,1508) and MPR View Height (0070,1512) attributes.
28.	Are conformance requirements proposed in Part 2 sufficient to document server behavior in a conformance statement? **Response:** Yes No public comment was received on this item
29.	When the Volumetric Metadata parameter is included in a request, should the response include only the Rendered Volume Response Module, or the Rendered Volume Response Module and the rendered media? **Response:** Only the Rendered Volume Response Module WG-27 prefers to return a single part for each for the following reasons: 1. With HTTP/2 and later versions, a user agent can make a rendering request as usual, and the origin server could provide the Rendered Volume Response Module in a push notification. 2. The ability of user agents to display video within a multipart/related response varies, so it may be impossible for some user agents to support direct viewing. 3. The general trend in PS3.18 is to provide separate endpoints.

Scope and Field of Application

This supplement introduces Volumetric Rendering web services to enable Volume Rendering (VR), Maximum Intensity Projection (MIP), and Multiplanar Planar Rendering (MPR) without having to specify numerous and complex parameters.

Web services enable a user agent to initiate server-side 3D volumetric rendering by specifying Query Parameters or a Volumetric Presentation State. The Resources introduced in this Supplement derive Query Parameters from Volumetric Presentation State attributes while maintaining alignment with current DICOMweb Studies Rendered Resources.

Modifications to PS3.2

Modify PS3.2 Section N.1.3.2 Studies Service as follows:

N.1.3.2 Studies Service

Table N.1-9 lists details on the support of the Studies Service.

[Complete Table N.1-9 to indicate support for the Studies Web Service]

Table N.1-9. Study Service

Service	Transaction	Resource	User Agent	Origin Server
Studies Web Service	Retrieve Capabilities			
	Retrieve (WADO-RS)	Study		
		Study Metadata		
		Study Bulkdata		
		Study Pixel Data		
		Rendered Study		
		Rendered MPR Volume Study		
		Rendered 3D Volume Study		
		Study Thumbnail		
		Series		
		Series Metadata		
		Series Bulkdata		
		Series Pixel Data		
		Rendered Series		
		Rendered MPR Volume Series		
		Rendered 3D Volume Series		
		Series Thumbnail		
		Instance		
		Instance Metadata		
		Instance Bulkdata		
		Instance Pixel Data		
		Rendered Instance		

		Rendered MPR Volume Instance		
		Rendered 3D Volume Instance		
		Instance Thumbnail		
		Frames		
		Rendered Frames		
		Rendered MPR Volume Frames		
		Rendered 3D Volume Frames		
		Frame Thumbnail		
		Bulkdata		
	…			

[If your Origin Server supports any Rendered MPR Volume Resources or Rendered 3D Volume Resources, indicate supported SOP Classes in the "Process" column of Table N.1-1]

Add Volumetric Rendering Resources to PS3.2 Table N.5-72 as follows:
Editorial note: this incorporates changes from cp2366.

Table N.5-72. Resources Retrieve Transaction - User Agent

Resource	Comments
DICOM Instance Resources - See Resources path in Table 10.4.1-1 in PS3.18	
Study Instances	
Series Instances	
Individual Instance	
DICOM Metadata Resources - See Resources path in Table 10.4.1-2 in PS3.18	
Study Metadata	
Series Metadata	
Instance Metadata	
DICOM Bulkdata Resources - See Resources path in Table 10.4.1.5-1 in PS3.18	
Study Bulkdata	
Series Bulkdata	
Instance Bulkdata	
Bulkdata	
DICOM Pixel Data Resources - See Resources path in Table 10.4.1.6-1 in PS3.18	
Study Pixel Data	
Series Pixel Data	
Instance Pixel Data	
Frame Pixel Data	
Rendered Resources - See Resources path in Table 10.4.1-3 in PS3.18	
Rendered Study	
Rendered Series	
Rendered Instance	
Rendered Frame	
Rendered MPR Volume Resources - See Resources path in Table 10.4.1.7-1 in PS3.18	
Rendered MPR Volume Study	
Rendered MPR Volume Series	
Rendered MPR Volume Instance	
Rendered MPR Volume Frames	

Rendered 3D Volume Resources - See Resources path in Table 10.4.1.8-1 in PS3.18	
Rendered 3D Volume Study	
Rendered 3D Volume Series	
Rendered 3D Volume Instance	
Rendered 3D Volume Frames	
Thumbnail Resources - See Resources path in Table 10.4.1-4 in PS3.18	
Study Thumbnail	
Series Thumbnail	
Instance Thumbnail	
Frame Thumbnail	

22 *Add Volumetric Rendering Query Parameters to PS3.2 Table N.5-73 as follows:*

23 *Note to editor: span rows for Rendered Resource and Thumbnail Resource*

24 **Table N.5-73. Query Parameters for Retrieve Transaction - User Agent**

Query Parameter	Supported Values	Comments
Accept	*[See examples in header parameters.]*	
Rendered Resource		
annotation	<<patient technique>>	
charset	<<UTF-8 ISO -8859-1 …>>	
quality		
viewport		
window		
iccprofile	<<no yes srgb adobergb rommrgb>>	
Rendered MPR Volume Resources		
volumeinputreference		
match	**Attribute Values to address the search (matching key). See the supported DICOM Attribute in the Table N.5-84**	
renderingmethod	**<<volume_rendered maximum_ip**	

	minimum_ip **average_ip>>**	
orientation		
viewpointposition		
viewpointlookat		
viewpointup		
mprslab		
volumetriccurvepoint		
animationstepsize		
animationrate		
renderedvolumetricmetadata		
Rendered 3D Volume Resources		
volumeinputreference		
match	**Attribute Values to address the search (matching key). See the supported DICOM Attribute in the Table N.5-84**	
renderingmethod	**<<volume_rendered** **maximum_ip** **minimum_ip** **average_ip>>**	
orientation		
viewpointposition		
viewpointlookat		
viewpointup		
swivelrange		
animationstepsize		
animationrate		
renderedvolumetricmetadata		
Thumbnail rResource		
charset	<<UTF-8 ISO-8859-1 …>>	
viewport		

Add Volumetric Rendering Header Fields to PS3.2 Table N.5-74 as follows:

Table N.5-74. Header Fields for Retrieve Transaction - User Agent

Header Field	Supported Values	Comments
…		
Rendered MPR Volume Resources		

Accept	**<<image/jpeg** **image/gif** **image/png** ***image/jp2*** ***image/jph*** ***image/jphc*** ***image/gif*** ***video/mpeg*** ***video/mp4*** ***video/H265*** ***multipart/related; type="application/dicom+xml"*** ***multipart/related; type="application/dicom+json">>***	**See details in Section N.5.3.2.1.3.**
Rendered MPR Volume Resources		
Accept	**<<image/jpeg** **image/gif** **image/png** ***image/jp2*** ***image/jph*** ***image/jphc*** ***image/gif*** ***video/mpeg*** ***video/mp4*** ***video/H265*** ***multipart/related; type="application/dicom+xml"*** ***multipart/related; type="application/dicom+json">>***	**See details in Section N.5.3.2.1.3.**
Thumbnail Resource		
…		

Add Volumetric Rendering Header Fields to PS3.2 Table N.5-74 as follows:

Editorial note: this incorporates changes from cp2366

Table N.5-75. Resources Retrieve Transaction - Origin Server

Resource	Comments
DICOM Instance Resources - See Resources path in Table 10.4.1-1 in PS3.18	
Study Instances	
Series Instances	
Individual Instance	
DICOM Metadata Resources - See Resources path in Table 10.4.1-2 in PS3.18	
Study Metadata	
Series Metadata	
Instance Metadata	
DICOM Bulkdata Resources - See Resources path in Table 10.4.1.5-1 in PS3.18	
Study Bulkdata	
Series Bulkdata	
Instance Bulkdata	
Bulkdata	
DICOM Pixel Data Resources - See Resources path in Table 10.4.1.6-1 in PS3.18	
Study Pixel Data	
Series Pixel Data	
Instance Pixel Data	
Frame Pixel Data	
Rendered Resources - See Resources path in Table 10.4.1-3 in PS3.18	
Rendered Study	
Rendered Series	
Rendered Instance	
Rendered Frame	
Rendered MPR Volume Resources - See Resources path in Table 10.4.1.7-1 in PS3.18	
Rendered MPR Volume Study	
Rendered MPR Volume Series	
Rendered MPR Volume Instance	
Rendered MPR Volume Frames	
Rendered 3D Volume Resources - See Resources path in Table 10.4.1.8-1 in PS3.18	
Rendered 3D Volume Study	
Rendered 3D Volume Series	
Rendered 3D Volume Instance	
Rendered 3D Volume Frames	
Thumbnail Resources - See Resources path in Table 10.4.1-4 in PS3.18	
Study Thumbnail	
Series Thumbnail	
Instance Thumbnail	
Frame Thumbnail	

Add Volumetric Rendering Query Parameters to PS3.2 Table N.5-76 as follows:

Note to editor: span rows for Rendered Resource and Thumbnail Resource

32 **Table N.5-76. Query Parameters for Retrieve Transaction - Origin Server**

Query Parameter	Supported Values	Comments
Accept	[Supported Values are the same as for the Accept Header Field.]	
Rendered ~~r~~Resource		
annotation	<<patient technique>> [Add additionally supported key word Values here.]	
charset	<<UTF-8 ISO-8859-1 …>>	
~~**Q**~~**q**uality		
~~**V**~~**v**iewport		
~~**W**~~**w**indow		
iccprofile	<<no yes srgb adobergb rommrgb>>	
Rendered MPR Volume Resources		
volumeinputreference		
match	**Attribute Values to address the search (matching key). See the supported DICOM Attribute in the Table N.5-84**	
renderingmethod	**<<volume_rendered** **maximum_ip** **minimum_ip** **average_ip>>**	
orientation		
viewpointposition		
viewpointlookat		
viewpointup		
mprslab		
volumetriccurvepoint		
animationstepsize		
animationrate		

renderedvolumetricmetadata		
Rendered 3D Volume Resources		
volumeinputreference		
match	**Attribute Values to address the search (matching key). See the supported DICOM Attribute in the Table N.5-84**	
renderingmethod	**<<volume_rendered** **maximum_ip** **minimum_ip** **average_ip>>**	
orientation		
viewpointposition		
viewpointlookat		
viewpointup		
swivelrange		
animationstepsize		
animationrate		
renderedvolumetricmetadata		
Thumbnail resource		
charset	<<UTF-8 ISO-8859-1 …>>	
~~***V***~~***v****iewport*		

33 *Add Volumetric Rendering Header Fields to PS3.2 Table N.5-77 as follows:*

34 **Table N.5-77. Header Fields for Retrieve Transaction - Origin Server**

Header Field	Supported Values	Comments
…		
Rendered MPR Volume Resources		

Accept	**<<image/jpeg** **image/gif** **image/png** ***image/jp2*** ***image/jph*** ***image/jphc*** ***image/gif*** ***video/mpeg*** ***video/mp4*** ***video/H265*** ***multipart/related; type="application/dicom+xml"*** ***multipart/related; type="application/dicom+json">>***	**See details in Section N.5.3.2.1.3.**
Rendered MPR Volume Resources		
Accept	**<<image/jpeg** **image/gif** **image/png** ***image/jp2*** ***image/jph*** ***image/jphc*** ***image/gif*** ***video/mpeg*** ***video/mp4*** ***video/H265*** ***multipart/related; type="application/dicom+xml"*** ***multipart/related; type="application/dicom+json">>***	**See details in Section N.5.3.2.1.3.**
Thumbnail Resource		
…		

Modifications to PS3.18

Add the following Section after Section 8.3.5.2:

8.3.5.3 Query Parameters for Rendered MPR Volume Resources and Rendered 3D Volume Resources

Query parameters defined in this section control the creation of new 3D or MPR images based on Volume Data resampled from the Target Resource.

The following rules pertain to all parameters defined in this section:

1. All parameters are optional for the user agent.
2. Not all parameters are required to be supported by the origin server.
3. These parameters only apply to resources that are images.

The set of transformations specified by the parameters in this section shall be applied to the images as if the parameters were a Volumetric Presentation State, that is, in the order specified by the applicable image rendering pipeline specified in Section FF.2 of PS3.4.

Table 8.3.5-2 shows the Query Parameters that may be used when requesting a Rendered Volume Representation.

Table 8.3.5-2. Retrieve Rendered Volume Query Parameters

Key	Values	Target Resource Category	Section
volumeinputreference	uid or frame	Image (single or multi-frame)	8.3.5.3.1
match	; See attribute matching rules in Section 8.3.4.1	Image (single or multi-frame)	8.3.5.3.2
renderingmethod	"volume_rendered", "maximum_ip" , "minimum_ip" or "average_ip"	Image (single or multi-frame)	8.3.5.3.3
orientation	"a", "p", "r", "l", "h" or "f"	Image (single or multi-frame) or Volumetric Presentation States	8.3.5.3.4
viewpointposition	px , py , pz	Image (single or multi-frame) or Volumetric Presentation States	8.3.5.3.5
viewpointlookat	lx , ly , lz	Image (single or multi-frame) or Volumetric Presentation States	8.3.5.3.6
viewpointup	ux , uy , uz	Image (single or multi-frame) or Volumetric Presentation States	8.3.5.3.7
mprslab	st	Image (single or multi-frame)	8.3.5.3.8
swivelrange	sr	Image (single or multi-frame)	8.3.5.3.9
volumetriccurvepoint	px , py , pz	Image (single or multi-frame)	8.3.5.3.10
animationstepsize	ss	Image (single or multi-frame)	8.3.5.3.11
animationrate	rt	Image (single or multi-frame)	8.3.5.3.12
renderedvolumetricmetadata	"yes"	Image (single or multi-frame)	8.3.5.3.13

Rendered MPR Volume Resources and Rendered 3D Volume Resources have two mutually exclusive options to determine the initial orientation of the resampled Volume Data:

1. The “orientation” parameter establishes the standard anatomic position of the patient as viewed by the camera, and
2. camera orientation parameters (“viewpointposition”, “viewpointlookat”, or “viewpointup”) establish the camera position and direction as it views the patient.

When incorporating animation parameters, the initial frame is established by orientation parameters. The parameters “swivelrange”, "volumetriccurvepoint" and “animationstepsize” dictate subsequent frames. When animating multiple sets of temporally related, spatially co-located Volume Data (such as a multiphase acquisition), the origin server determines the initial frame’s displayed phase.

There is no parameter to control the type of projection used during rendering. The origin server shall use Orthographic projection for Rendered 3D Volume Resources. See Section C.11.30.1 in PS3.3.

There is no parameter to explicitly control Render Field of View, MPR View Height or MPR View Width (see Sections C.11.30 and C.11.26 in PS3.3). The “viewport” parameter can be used to scale the returned media. See Section 8.3.5.1.3.

8.3.5.3.1 Volume Input Reference

The “volumeinputreference” parameter identifies the Instance, or Frame within an Instance, from which the origin server shall extract characteristics and identify additional Instances or Frames in the Target Resource with the same values for those characteristics. The user agent uses this parameter to identify a desired subset when the Target Resource is a superset of the intended Volume Data. The origin server shall identify a subset that conforms to the Volume Input Requirements for Rendered MPR Volume Resources and Rendered 3D Volume Resources (see PS3.3, Section C.11.23.1).

The syntax of this parameter for a multi-frame image is:

```
%s" volumeinputreference =" uid "," frame
```

Otherwise, it is:

```
%s" volumeinputreference =" uid
```

Where

`uid`	Is the Unique Identifier of the Volume Input Reference SOP Instance when the Target Resource is a series or study.
`frame`	Is the frame number within an Image Instance when the Volume Input Reference is an Enhanced IOD Image Instance.

Note

`uid` corresponds to Referenced SOP Instance UID (0008,1155) and `frame` corresponds to Referenced Frame Number (0008,1160) See Section 10.3 in PS3.3.

The origin server shall create Volume Data from instances or frames having characteristics identical to the Volume Input Reference based on implementation-specific logic.

The origin server shall return a 400 (Bad Request), and may include an appropriate Status Report, if any of the following are true:

- the Target Resource is a Presentation State,
- valid Volume Data is not found based on the Volume Input Reference,
- the UID is not found in the Target Resource,
- the frame is not found in the Target Resource,
- a Match Attribute/Value pair is present in another parameter in the request.

8.3.5.3.2 Match

The “match” parameter specifies common DICOM Attribute/Value pair characteristics of the Volume Data.

When the user agent identifies a Target Resource that is a superset of the intended Volume Data, it may identify Attribute/Value pairs that specify matching criteria to identify specific Instances or Frames in the Target Resource to resample as Volume Data. The resulting subset shall conform to the Volume Input Requirements for Rendered MPR Volume Resources and Rendered 3D Volume Resources (see PS3.3, Section C.11.23.1).

See Section 8.3.4.1 for the syntax of this parameter.

The user agent may include the following Attributes in the parameter:

- Instance IE Attributes
- Private Data Element Tags and their corresponding Private Creator Element Tags

The origin server shall reconstruct Volume Data meeting the Volume Input Criteria.

The origin server shall return a 400 (Bad Request), and may include an appropriate Status Report, if any of the following are true:

- the Target Resource is a Volumetric Presentation State,
- valid Volume Data is not found based on the Attribute/Value pair,
- the “volumeinputreference” parameter is also present.

8.3.5.3.3 Rendering Method

The "renderingmethod" parameter specifies the display algorithm to be applied to the Volume Data.

The syntax of this parameter is:

```
%s"renderingmethod=" 1#( %s"volume_rendered" / %s"maximum_ip" / %s"minimum_ip" /
%s"average_ip" )
```

Where

`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.
`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.
`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.

Notes

1. These values correspond to the differently capitalized values of Rendering Method (0070,120D). See Sections C.11.23 and C.11.30 in PS3.3.
2. There is no parameter to control the type of projection used during rendering. Rendered 3D Volume Resources use Orthographic projection. See Figure C.11.30-1 in PS3.3.
3. For Rendered MPR Volume resources, this parameter describes the display algorithm to apply when the slab thickness is greater than one voxel. This parameter value is typically average_ip.

If "renderingmethod" is not present, the origin server may apply a default rendering method, based on the resource, or alternatively, return 400 (Bad Request) and may include an appropriate Status Report.

If the Target Resource is a Volumetric Presentation State, the origin server shall return a 400 (Bad Request) and may include an appropriate Status Report.

8.3.5.3.4 Orientation

The "orientation" parameter specifies the patient's orientation as seen by the camera for the current 3D or MPR Volumetric Presentation View.

The syntax of this parameter is:

```
%s"orientation =" 1#( %s"a" / %s"p" / %s"r" / %s"l" / %s"h" / %s"f" )
```

Where

`a` The camera is viewing the patient's anterior:
- Viewpoint Position (0070,1603) is anterior to the patient.
- Viewpoint LookAt Direction (0070,1604) is from the patient's anterior towards the patient's posterior.
- Viewpoint Up Direction (0070,1605) is towards the patient's superior.

`p` The camera is viewing the patient's posterior:
- Viewpoint Position (0070,1603) is posterior to the patient.
- Viewpoint LookAt Direction (0070,1604) is from the patient's posterior towards the patient's anterior.
- Viewpoint Up Direction (0070,1605) is towards the patient's superior.

`r` The camera is viewing the patient's right side:
- Viewpoint Position (0070,1603) is to the patient's right.
- Viewpoint LookAt Direction (0070,1604) is from the patient's right towards the patient's left.
- Viewpoint Up Direction (0070,1605) is towards the patient's superior.

`l` The camera is viewing the patient's left side:
- Viewpoint Position (0070,1603) is to the patient's left.
- Viewpoint LookAt Direction (0070,1604) is from the patient's left towards the patient's right.
- Viewpoint Up Direction (0070,1605) is towards the patient's superior.

`h` The camera is viewing the patient's head (i.e., from above):
- Viewpoint Position (0070,1603) is superior to the patient.
- Viewpoint LookAt Direction (0070,1604) is from the patient's superior towards the patient's inferior.
- Viewpoint Up Direction (0070,1605) is towards the patient's anterior.

`f` The camera is viewing the patient's feet (i.e., from below):
- Viewpoint Position (0070,1603) is inferior to the patient.
- Viewpoint LookAt Direction (0070,1604) is from the patient's inferior towards the patient's superior.
- Viewpoint Up Direction (0070,1605) is towards the patient's anterior.

Note

These values correspond to the differently capitalized values of the Patient Orientation (0020,0020) and Image Orientation (Patient) (0020,0037). See Section C.7.6.1.1.1 in PS3.3 and Section A in PS3.17.

If the Target Resource is a Volumetric Rendering Presentation State and any orientation Query Parameters are present, the origin server shall apply the query parameter(s) instead of the geometry attributes in the Multi-Planar Reconstruction Geometry Module, or the Volume Render Geometry Module.

Note

This is intended to allow the user to adjust orientation after viewing the initial orientation defined in the Volumetric Presentation State.

Orientation is used to select the desired standard anatomic position of the rendered volume. For example, "a" specifies the direction of the rendered volume that most closely aligns with the patient's anterior plane. Viewing angles beyond the standard orthogonal anatomic positions are controlled by camera orientation parameters (i.e., "viewpointposition", "viewpointlookat", or "viewpointup").

The origin server shall determine a Viewpoint Position (0070,1603), a Viewpoint LookAt Direction (0070,1604) and a Viewpoint Up Direction (0070,1605) based on the value of the "orientation" parameter.

If both the "orientation" parameter and any of the camera orientation parameters are present, the origin server shall return a 400 (Bad Request) and may include an appropriate Status Report.

8.3.5.3.5 Viewpoint Position

The "viewpointposition" parameter specifies the position of the camera in the Viewpoint Coordinate System (VCS). See Section C.11.30.1 in PS3.3.

The syntax of this parameter is:

```
%s"viewpointposition =" px "," py "," pz
```

Where

`px, py and pz` Position of the viewpoint in volume space. A point (x,y,z) in the VCS.

Note

This corresponds to the Viewpoint Position (0070,1603) attribute. See Section C.11.30 in PS3.3.

If the Target Resource is a Volumetric Rendering Presentation State and any orientation Query Parameters are present, the origin server shall apply the query parameter(s) instead of the geometry attributes in the Multi-Planar Reconstruction Geometry Module, or the Volume Render Geometry Module.

Any or all of the camera orientation parameters may be included. If any of the camera orientation Query Parameters are absent, the origin server may apply a default value (e.g.,

- set "viewpointposition" to the patient's anterior,
- set "viewpointlookat" to the center of volume,
- set "viewpointup" to the patient's superior),

or return a 400 (Bad Request) and may include an appropriate Status Report.

8.3.5.3.6 Viewpoint LookAt

The "viewpointlookat" parameter specifies the point that the camera is looking at within the Viewpoint Coordinate System (VCS). See Section C.11.30.1 in PS3.3.

The syntax of this parameter is:

```
%s"viewpointlookat =" lx "," ly "," lz
```

Where

`lx, ly and lz`	Viewpoint LookAt point (i.e., the point that the camera is looking at). A point (x,y,z) in the VCS.

Note

This corresponds to the Viewpoint LookAt Point (0070,1604) attribute. See Section C.11.30 in PS3.3.

If the Target Resource is a Volumetric Rendering Presentation State and any orientation Query Parameters are present, the origin server shall apply the query parameter(s) instead of the geometry attributes in the Multi-Planar Reconstruction Geometry Module, or the Volume Render Geometry Module.

8.3.5.3.7 Viewpoint Up

The "viewpointup" parameter specifies the vertical orientation of the camera within the Viewpoint Coordinate System (VCS). See Section C.11.30.1 in PS3.3.

The syntax of this parameter is:

```
%s"viewpointup =" ux "," uy "," uz
```

Where

`ux, uy and uz`	Viewpoint up direction (i.e., the direction that the top of the camera is pointing to). A vector (x,y,z) in the VCS.

Note

This corresponds to the Viewpoint Up Direction (0070,1605) attribute. See Section C.11.30 in PS3.3.

If the Target Resource is a Volumetric Rendering Presentation State and any orientation Query Parameters are present, the origin server shall apply the query parameter(s) instead of the geometry attributes in the Multi-Planar Reconstruction Geometry Module, or the Volume Render Geometry Module.

8.3.5.3.8 MPR Slab Thickness

The "mprslab" parameter specifies the thickness of the MPR plane. This parameter results in an orthographic rendering with a defined thickness using the method defined by "renderingmethod". See PS3.3 Section C.11.26.1.1 for more information.

The syntax of this parameter for a Rendered MPR Volume is:

```
%s"mprslab =" st
```

Where

`st`	Thickness of the Multi-Planar Reconstruction slab as a value greater than zero, in mm.

Notes

1. This corresponds to the MPR Slab Thickness (0070,1503) attribute. See Section C.11.26 in PS3.3.
2. The slab thickness of the returned media might not match the requested thickness due to the voxel size of the Target Resource.

If "renderingmethod" is not present, the origin server may apply a default rendering method, based on the resource and/or slab thickness, or alternatively, return 400 (Bad Request) and may include an appropriate Status Report.

If the Target Resource is a Volumetric Presentation State, the origin server shall return a 400 (Bad Request) and may include an appropriate Status Report.

8.3.5.3.9 Swivel Range

The "swivelrange" parameter specifies the angular range over which a rendered volume rotates around the swivel axis, which is defined as the axis parallel to the “viewpointup“ intersecting the “viewpointlookat”. The rendered volume rotates back and forth.

The syntax of this parameter is:

```
%s"swivelrange =" sr
```

Where

`sr` Range in which a volume rotates back-and-forth around the swivel axis, in degrees.

Note

This corresponds to the differently capitalized SWIVEL value of Presentation Animation Style (0070,1A01) and Swivel Range (0070,1A06). See Section C.11.29 in PS3.3 and Section FF.2.4.2 in PS3.4.

The origin server shall create an animation with a number of frames equal to Swivel Range divided by the "animationstepsize".

If the “swivelrange” parameter is present and the “animationrate” parameter is not present, the origin server shall determine the animation rate.

If the Target Resource is a Volumetric Presentation State, the origin server shall return a 400 (Bad Request) and may include an appropriate Status Report.

8.3.5.3.10 Volumetric Curve Point Coordinates

The "volumetriccurvepoint" parameter specifies coordinates of points on the animation 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. At least two points are required for an animation. See Section C.11.29.1 in PS3.3.

The syntax of this parameter is:

```
%s" volumetriccurvepoint =" px "," py "," pz
```

Where

`px, py and pz` Position of a point on the animation curve. A point (x,y,z) in the VPS-RCS, in mm.

Note

This corresponds to the Volumetric Curve Points (0070,150D) attribute. See Section C.11.29 in PS3.3.

The origin server shall create an animation with a number of frames equal to the total distance of the Volumetric Curve divided by the "animationstepsize".

If the "volumetriccurvepoint" parameters are present and the “animationrate” parameter is not present, the origin server shall determine the animation rate.

If the Target Resource is a Volumetric Presentation State, the origin server shall return a 400 (Bad Request) and may include an appropriate Status Report.

8.3.5.3.11 Animation Step Size

The "animationstepsize" parameter specifies distance between animation steps, or frames, in a Volumetric Rendering animation.

For a swivel animation, the distance between steps is in degrees. For a Volumetric Curve, the distance between steps is in mm along the animation curve.

The syntax of this parameter is:

```
%s" animationstepsize =" ss
```

Where

`ss` The animation step size, an integer greater than zero.

Note

This corresponds to the Number of Animation Step Size (0070,1A05) attribute. See Section C.11.29 in PS3.3.

The origin server shall create an animation, with a number of frames equal to either:

- the “swivelrange” divided by the "animationstepsize", or
- the total distance of the Volumetric Curve divided by the "animationstepsize".

If " animationstepsize " is not present, and either “swivelrange”, or “volumetriccurvepoint” are present, the origin server may apply a default animation step size, or alternatively, return 400 (Bad Request) and may include an appropriate Status Report.

If the Target Resource is a Volumetric Presentation State, the origin server shall return a 400 (Bad Request) and may include an appropriate Status Report.

8.3.5.3.12 Animation Rate

The “animationrate” parameter specifies the rate at which an animated 3D or MPR Volumetric Presentation is displayed.

The syntax of this parameter is:

```
%s" animationrate =" rt
```

Where

`rt` Rate in steps per second, an integer greater than zero.

Notes

1. This corresponds to Recommended Animation Rate (0070,1A03) in Section C.11.29 in PS3.3 and Section FF.2.4.2 in PS3.4.
2. Playback of the returned media on a client may or may not achieve the requested animation rate.

If " animationrate" is not present, and other animation parameters are present (e.g., “swivelrange”, “animationstepsize”, or “volumetriccurvepoint”), the origin server may apply a default animation rate, or alternatively, return 400 (Bad Request) and may include an appropriate Status Report.

If the Target Resource is a Volumetric Presentation State, the origin server shall return a 400 (Bad Request) and may include an appropriate Status Report.

8.3.5.3.13 Rendered Volumetric Metadata

The "renderedvolumetricmetadata" parameter specifies that the response payload contains only a Rendered Volume Response Module of the parameters applied by the origin server to generate the volumetric rendering.

The syntax of this parameter is:

```
%s"renderedvolumetricmetadata =" "yes"
```

Where

`yes`	Indicates that only the Rendered Volume Response Module shall be present in the response payload.

The origin server shall return a response payload containing a Rendered Volume Response Module as specified in Annex X.

Note

If this parameter is not present, no Response Module is requested and the 2D representation of the rendered volume is returned as described in Sections 10.4.1.1.7 and 10.4.1.1.8.

The Rendered Volume Response Module contains the complete set of query parameters, including both those specified by the user agent in the request and those determined by the origin server.

For any two requests where the query parameters, Target Resource, and header fields are identical, the query parameter values in the Rendered Volume Response Module returned by the origin server shall be identical.

Note

When repeating a rendering request, the origin server is expected to deliver a result that is consistent. It is not mandatory for it to be precisely identical.

If the Target Resource is a Volumetric Presentation State, the origin server shall return a 400 (Bad Request) and may include an appropriate Status Report.

Update PS3.18 Section 8.11 as follows:

8.11 Security and Privacy

It is very likely that DICOM objects contain Protected Health Information. Privacy regulations in the United States (HIPAA), Europe (GDPR), and elsewhere, require that Individually Identifiable Information be kept private. It is the responsibility of those implementing and deploying the DICOM Standard to ensure that applicable regulations for security and privacy are satisfied.

See, for example, [ONC Privacy Security Guide].

Some types of images, such as rendered volumes, or the source slices from which they are created, may include recognizable visual features.

The DICOM PS3.10 File Format has security considerations that will apply whenever DICOM PS3.10 File format is used. See Section 7.5 in PS3.10.

Modify Table 10.1-1. Resources and Descriptions as follows:

Table 10.1-1. Resources and Descriptions

Resource	Description
Studies Service	The Base URI of the Studies Service.
All Studies	The All Studies resource references the entire collection of Studies contained in the Studies Service.
Study	The Study resource references a single Study.
Study Metadata	The Study Metadata resource references the Metadata of a Study.
Study Bulkdata	The Study Bulkdata resource references the Bulkdata of a Study.
Study Pixel Data	The Study Pixel Data resource references the Pixel Data of a Study.
Rendered Study	The Rendered Study resource references **an alternate media type rendering of** a Study. ~~**to be rendered**~~
Rendered MPR Volume Study	**The Rendered MPR Volume Study resource references a multiplanar reformat rendering of a Study.**
Rendered 3D Volume Study	**The Rendered 3D Volume Study resource references a volume rendering of a Study.**
Study Thumbnail	The Study Thumbnail resource references a thumbnail image of a Study.
Study's Series	The Study's Series resource references the collection of all Series contained in a Study.
Study's Instances	The Study's Instances resource references the collection of all Instances in a single Study.
All Series	The All Series resource references the collection of all Series in all Studies contained in the Studies Service.
Series	The Series resource references a single Series.
Series Metadata	The Series Metadata resource contains the Metadata of a Series in a Study.
Series Bulkdata	The Series Bulkdata resource references the Bulkdata of a Series.
Series Pixel Data	The Series Pixel Data resource references the Pixel Data of a Series.
Rendered Series	The Rendered Series resource references **an alternate media type rendering of** a Series. ~~**to be rendered**~~
Rendered MPR Volume Series	**The Rendered MPR Volume Series resource references a multiplanar reformat rendering of a Series.**
Rendered 3D Volume Series	**The Rendered 3D Volume Series resource references a volume rendering of a Series.**
Series Thumbnail	The Series Thumbnail resource references a thumbnail image of a Series.

Resource	Description
Series' Instances	The Series' Instances resource references the collection of all Instances in a single Series.
All Instances	The All Instances resource references the collection of all Instances in all Series in all Studies contained in the Studies Service.
Instance	The Instance resource references a single Instance.
Instance Metadata	The Instance Metadata resource contains the Metadata of an Instance.
Instance Bulkdata	The Instance Bulkdata resource references the Bulkdata of a**n** Instance.
Instance Pixel Data	The Instance Pixel Data resource references the Pixel Data of a**n** Instance.
Rendered Instance	The Rendered Instance resource references **an alternate media type rendering of** an Instance. ~~**to be rendered**~~
Rendered MPR Volume Instance	**The Rendered MPR Volume Instance resource references a multiplanar reformat rendering of an Instance.**
Rendered 3D Volume Instance	**The Rendered 3D Volume Instance resource references a volume rendering of an Instance.**
Instance Thumbnail	The Instance Thumbnail resource references a thumbnail image of an Instance.
Frames	The Frames resource references an ordered collection of frames in a single multi-frame Instance.
Rendered Frames	The Rendered Frames resource references **an alternate media type rendering of** an ordered collection of frames of a single multi-frame Instance. ~~**to be rendered**~~
Rendered MPR Volume Frames	**The Rendered MPR Volume Frames resource references a multiplanar reformat rendering of a collection of frames.**
Rendered 3D Volume Frames	**The Rendered 3D Volume Frames resource references a volume rendering of a collection of frames.**
Frame Thumbnail	The Frame Thumbnail resource references a thumbnail image for frames within an Instance.
Bulkdata	The Bulkdata resource contains a Bulkdata Value.

Update PS3.18 Table 10.3-2 Resources by Transaction as follows:

In Table 10.3-2, the Target Resources permitted for each transaction are marked with M if support is mandatory for the origin server and O if it is optional. A blank cell indicates that the resource is not allowed in the transaction.

Table 10.3-2. Resources by Transaction

Resource	Retrieve	Store	Search
Studies Service			
All Studies		M	M

Study	M	M	
Study Metadata	M		
Study Bulkdata	O		
Study Pixel Data	O		
Rendered Study	M		
Rendered MPR Volume Study	**O**		
Rendered 3D Volume Study	**O**		
Study Thumbnail	O		
Study's Series			M
Study's Instances			M
All Series			M
Series	M		
Series Metadata	M		
Series Bulkdata	O		
Series Pixel Data	O		
Series' Instances			M
Rendered Series	M		
Rendered MPR Volume Series	**O**		
Rendered 3D Volume Series	**O**		
Series Thumbnail	O		
All Instances			M
Instance	M		
Instance Metadata	M		
Instance Bulkdata	O		
Instance Pixel Data	O		
Rendered Instance	M		
Rendered MPR Volume Instance	**O**		
Rendered 3D Volume Instance	**O**		

Instance Thumbnail	O		
Frames	M		
Rendered Frames	M		
Rendered MPR Volume Frames	**O**		
Rendered 3D Volume Frames	**O**		
Frame Thumbnail	O		
Bulkdata	M	M	

Add the following Sections after Section 10.4.1.1.6:

10.4.1.1.7 Rendered MPR Volume Resources

Rendered MPR Volume Resources (defined in Table 10.4.1.7-1) are used to retrieve representations of a DICOM Resource after performing multiplanar reformatting. Reformatting represents a cross-section of a volume of slice data as an Euclidean plane in accordance with the principles established for Planar MPR Volumetric Presentation States (see PS3.4, Section FF.2.1.1). Rendered images are returned as Acceptable Media Types in the response payload.

Note

These resources ensure uniform client requests and reasonably consistent rendering outcomes. Due to inherent differences in algorithm implementations, an identical match of rendering results between different implementations is not assured.

The Target Resource shall be either:

- a Planar MPR Volumetric Presentation State Instance, or
- a collection of Image Instances or frames within Image Instances that conform to the Volume Input Requirements for Rendered MPR Volume Resources (see PS3.3, Section C.11.23.1)
- a collection of Image Instances or frames within Image Instances, refined using one of the Query Parameters defined in Section 8.3.5.3, to meet Volume Input Requirements for Rendered MPR Volume Resources (see PS3.3, Section C.11.23.1).

Table 10.4.1.7-1. Retrieve Transaction Rendered MPR Volume Resources

Resource	URI Template
Rendered MPR Volume Study	/studies/{study}/renderedmpr
Rendered MPR Volume Series	/studies/{study}/series/{series}/renderedmpr
Rendered MPR Volume Instance	/studies/{study}/series/{series}/instances/{instance}/renderedmpr
Rendered MPR Volume Frames	/studies/{study}/series/{series}/instances/{instance}/frames/{frames}/renderedmpr

Note

The URI template for a Rendered MPR Volume Instance may apply to a multi-frame image instance being rendered, or to a Volume Rendering Volumetric Presentation State instance.

10.4.1.1.8 Rendered 3D Volume Resources

Rendered 3D Volume Resources (defined in Table 10.4.1.8-1) are used to retrieve representations of a DICOM Resource rendered after performing 3D rendering, in accordance with the principles established for Volume Rendering Volumetric Presentation States (see PS3.4, Section FF.2.1.2), by applying thresholding, ray-casting, volume rendering, or other methods to display a volume of slice data as a three-dimensional projection. Rendered images are returned as Acceptable Media Types in the response payload.

Note

These resources ensure uniform client requests and reasonably consistent rendering outcomes. Due to inherent differences in algorithm implementations, an identical match of rendering results between different implementations is not assured.

The Target Resource shall be either:

- a Planar MPR Volumetric Presentation State Instance, or
- a collection of Image Instances or frames within Image Instances that conform to the Volume Input Requirements for Rendered 3D Volume Resources (see PS3.3, Section C.11.23.1)
- a collection of Image Instances or frames within Image Instances, refined using one of the Query Parameters defined in Section 8.3.5.3, to meet Volume Input Requirements for Rendered 3D Volume Resources (see PS3.3, Section C.11.23.1).

Table 10.4.1.8-1. Retrieve Transaction Rendered 3D Volume Resources

Resource	URI Template
Rendered 3D Volume Study	/studies/{study}/series/rendered3d
Rendered 3D Volume Series	/studies/{study}/series/{series}/rendered3d
Rendered 3D Volume Instance	/studies/{study}/series/{series}/instances/{instance}/rendered3d
Rendered 3D Volume Frames	/studies/{study}/series/{series}/instances/{instance}/frames/{frames}/rendered3d

Note

The URI template for a Rendered 3D Volume Instance may apply to a multiframe image instance being rendered, or to a Planar MPR Volumetric Presentation State instance.

Modify Table 10.4.1-5. Query Parameters by Resource as follows:

Note: The "M" values in the table are not breaking changes because the origin server does not have to support an "M" unless it supports a resource encompassed by the value in the Resources column.

10.4.1.2 Query Parameters

The origin server shall support Query Parameters as required in Table 10.4.1-5.

The user agent shall supply in the request Query Parameters as required in Table 10.4.1-5.

Table 10.4.1-5. Query Parameters by Resource

Key	Resources	Usage	Section

		User Agent	Origin Server	
accept	All Resources	O	M	Section 8.3.3.1
charset	Metadata Resources	O	M	Section 8.3.3.2
annotation	Rendered Resources	O	M	Section 8.3.5.1.1
	Rendered MPR Volume Resources	**O**	**O**	
	Rendered 3D Volume Resources	**O**	**O**	
quality	Rendered Resources	O	M	Section 8.3.5.1.2
	Rendered MPR Volume Resources	**O**	**O**	
	Rendered 3D Volume Resources	**O**	**O**	
viewport	Rendered Resources	O	M	Section 8.3.5.1.3
	Rendered MPR Volume Resources	**O**	**O**	
	Rendered 3D Volume Resources	**O**	**O**	
	Thumbnail Resources	O	O	
window	Rendered Resources	O	M	Section 8.3.5.1.4
	Rendered MPR Volume Resources	**O**	**O**	
	Rendered 3D Volume Resources	**O**	**O**	
iccprofile	Rendered Resources	O	O	Section 8.3.5.1.5
	Rendered MPR Volume Resources	**O**	**O**	
	Rendered 3D Volume Resources	**O**	**O**	
volumeinputreference	**Rendered MPR Volume Resources**	**O**	**O**	**Section 8.3.5.3.1**
	Rendered 3D Volume Resources	**O**	**O**	
match	**Rendered MPR Volume Resources**	**O**	**O**	**Section 8.3.5.3.2**
	Rendered 3D Volume Resources	**O**	**O**	
renderingmethod	**Rendered MPR Volume Resources**	**O**	**M**	**Section 8.3.5.3.3**
	Rendered 3D Volume Resources	**O**	**M**	
orientation	**Rendered MPR Volume Resources**	**O**	**O**	**Section 8.3.5.3.4**
	Rendered 3D Volume Resources	**O**	**O**	
viewpointposition	**Rendered MPR Volume Resources**	**O**	**M**	**Section 8.3.5.3.5**
	Rendered 3D Volume Resources	**O**	**M**	
viewpointlookat	**Rendered MPR Volume Resources**	**O**	**M**	**Section 8.3.5.3.6**
	Rendered 3D Volume Resources	**O**	**M**	
viewpointup	**Rendered MPR Volume Resources**	**O**	**M**	**Section 8.3.5.3.7**
	Rendered 3D Volume Resources	**O**	**M**	
mprslab	**Rendered MPR Volume Resources**	**O**	**M**	**Section 8.3.5.3.8**
swivelrange	**Rendered 3D Volume Resources**	**O**	**O**	**Section 8.3.5.3.9**
volumetriccurvepoint	**Rendered MPR Volume Resources**	**O**	**O**	**Section 8.3.5.3.10**
animationstepsize	**Rendered MPR Volume Resources**	**O**	**O**	**Section 8.3.5.3.11**
	Rendered 3D Volume Resources	**O**	**O**	
animationrate	**Rendered MPR Volume Resources**	**O**	**O**	**Section 8.3.5.3.12**
	Rendered 3D Volume Resources	**O**	**O**	
renderedvolumetricmetadata	**Rendered MPR Volume Resources**	**O**	**M**	**Section 8.3.5.3.13**
	Rendered 3D Volume Resources	**O**	**M**	

Add the following Section after 10.4.3.3.6 Pixel Data Resource Payload:

10.4.3.3.7 Rendered Volume Resource Payload

The payload for a Rendered 3D Volume Resource (see Section 10.4.1.1.7) or a Rendered MPR Volume Resource (see Section 10.4.1.1.8) shall contain:

- a 2D representation of the rendered volume according to the parameters of the display algorithm,

or,

- a Rendered Volume Resources Response Module (see Annex X) corresponding to the request. See Section B.x2 for an example.

A failure response payload may contain a Status Report describing any failures, warnings, or other useful information.

Add the following Sections after Section B.25:

B.x1 Render a Series as a 3D Volume

This example illustrates a request to render a series as a 3D volume, returned as a jpeg. The series contains legacy instances. Since no other parameters are specified, they are determined by the origin server.

```
GET /radiology
/studies/1.2.250.1.59.40211.12345678.678910
/series/1.2.250.1.59.40211.789001276.14556172.67789
/rendered3D?renderingmethod=volume_rendered
HTTP/1.1
Host: www.hospital-stmarco
Accept: image/jpeg

HTTP/1.1 200 OK
Content-Length: 79323
Content-Type: image/jpeg
<BINARY JPEG DATA>
```

B.x2 Render a Multi-frame Instance as a 3D Volume Rendering

This example illustrates a request for a Rendered Volume Response Module representing the rendering of a multi-frame instance as a 3D volume, returned as an mp4 video animating an initial view oriented from the patient's anterior, swiveled 180 degrees at 20fps. Since the orientation is specified as anterior, the server determines camera orientation equivalents. The swivel axis is aligned with the Viewpoint Up Direction (0070,1605), which is oriented towards the patient's superior, intersecting the Viewpoint LookAt Point (0070,1604), which is directed from the anterior towards the posterior, resulting in a swivel around the superior-inferior axis. Since the animation step size is not specified, it is determined by the origin server and included with the requested volumetric metadata in the Rendered Volume Response Module.

Notes

The request encodes the orientation as "Anterior". The Rendered Volume Response Module encodes camera orientation as described in Section 8.3.5.3.

```
GET /radiology
/studies/1.2.250.1.59.40211.12345678.678910
```

```
/series/1.2.250.1.59.40211.789001276.14556172.67789
/instances/1.2.250.1.59.40211.2678810.87991027.899772.2
/rendered3D?renderingmethod=volume_rendered
&orientation=a
&swivelrange=180
&animationrate=20
&renderedvolumetricmetadata=yes
HTTP/1.1
Host: www.hospital-stmarco
Accept: application/dicom+json

HTTP/1.1 200 OK
Content-Length: 369
Content-Type: application/dicom+json
{
    "00720510": {
        "vr": "CS",
        "Value": ["3D_RENDERING"]
    },
    "0070120D": {
        "vr": "CS",
        "Value": ["VOLUME_RENDERED"]
    },
    "00801603": {
        "vr": "FD",
        "Value": [100,101,200]
    },
    "00801604": {
        "vr": "FD",
        "Value": [100,100,200]
    },
    "00801605": {
        "vr": "FD",
        "Value": [0,0,1]
    },
    "00701A06": {
        "vr": "FD",
        "Value": [180]
    },
    "00701A05": {
        "vr": "FD",
        "Value": [1.8]
    },
    "00701A03": {
        "vr": "FD",
        "Value": [20]
}
```

B.x3 Render a Study as an MPR

This example illustrates a request to render a study as an MPR, returned as a 30fps mp4 video animating an Oblique orientation (specified using viewpoint parameters). The request also specifies a window width of 400 and center of 40 and a rendering method of average intensity projection. The user agent specifies that the rendered instances should consist of the multi-phase cardiac acquisition frames for the R-R interval between 140 and 260 milliseconds.

Note

See PS3.4 Section C2.2.2 for Attribute Matching.

The origin server will need to identify the relevant instances in the study (based on the presence of Cardiac R-R Interval Specified (0018,9070) with matching values). Since an animation step size was not specified, and a temporal range is specified (for the cardiac R-R interval), the origin server understands that a temporal animation of multiple series each containing a single phase is requested. Since MPR slab thickness is not specified, the server renders a thin MPR, meaning a minimally thick slab of unspecified thickness.

```
GET /radiology
/studies/1.2.250.1.59.40211.12345678.678910/renderedmpr?
CardiacRRIntervalSpecified=140-260
&renderingmethod=average_ip
&viewpointposition=532,38,126
&viewpointlookat=-532,-76,-154
&viewpointup=0,0,0
&animationrate=30
&window=400,40,linear
HTTP/1.1
Host: www.hospital-stmarco
Accept: video/mp4

HTTP/1.1 200 OK
Content-Length: 3145728
Content-Type: video/mp4
<BINARY MPEG-4 DATA>
```

B.x4 Render One Phase of a Multi-phase Series as an MIP

This example illustrates a request for a static MPR rendering of one phase of a multi-phase series. A volume input reference is provided to identify the desired phase. Coronal orientation is specified using camera orientation parameters. The MPR MIP is 20mm thick and windowed at a width of 700 and center of 100. The returned jpeg is scaled to a matrix size of 256 by 256.

```
GET /radiology
/studies/1.2.250.1.59.40211.12345678.678910
/series/1.2.250.1.59.40211.789001276.14556172.67789/renderedmpr?
volumeinputreference=1.2.250.1.59.40211.2678810.87991027.899772.2
&renderingmethod=maximum_ip
&mprslab=20
&viewpointposition=100,101,200
&viewpointlookat=100,100,200
&viewpointup=0,0,1
&viewport=256,256
&window=700,100,linear
HTTP/1.1
Host: www.hospital-stmarco
Accept: image/jpeg

HTTP/1.1 200 OK
Content-Length: 79323
Content-Type: image/jpeg
<BINARY JPEG DATA>
```

Update PS3.18 Table H-1. Resources and Methods as follows:

Table H-1. Resources and Methods

Studies (see Section 10.1.1)			
	studies	Search for Studies	Section 10.6
		Store Instances	Section 10.5

	{StudyInstance}	Retrieve Study Store Study Instances	Section 10.4 Section 10.5
	metadata	Retrieve Study Metadata	Section 10.4
	rendered	Retrieve Rendered Study	Section 10.4
	renderedmpr	**Retrieve Rendered MPR Volume Study**	**Section 10.4**
	rendered3d	**Retrieve Rendered 3D Volume Study**	**Section 10.4**
	thumbnail	Retrieve Study Thumbnail	Section 10.4
	bulkdata	Retrieve Study Bulkdata	Section 10.4
	pixeldata	Retrieve Study Pixel Data	Section 10.4
	series	Search for Study Series	Section 10.6
	{SeriesInstance}	Retrieve Series	Section 10.4
	metadata	Retrieve Series Metadata	Section 10.4
	rendered	Retrieve Rendered Series	Section 10.4
	renderedmpr	**Retrieve Rendered MPR Volume Series**	**Section 10.4**
	rendered3d	**Retrieve Rendered 3D Volume Series**	**Section 10.4**
	thumbnail	Retrieve Series Thumbnail	Section 10.4
	bulkdata	Retrieve Series Bulkdata	Section 10.4
	pixeldata	Retrieve Series Pixel Data	Section 10.4
	instances	Search for Study Series Instances	Section 10.4
	{SOPInstance}	Retrieve Instance	Section 10.4
	metadata	Retrieve Instance Metadata	Section 10.4
	rendered	Retrieve Rendered Instance	Section 10.4
	renderedmpr	**Retrieve Rendered MPR Volume Instance**	**Section 10.4**
	rendered3d	**Retrieve Rendered 3D Volume Instance**	**Section 10.4**
	thumbnail	Retrieve Instance Thumbnail	Section 10.4
	bulkdata	Retrieve Instance Bulkdata	Section 10.4
	pixeldata	Retrieve Instance Pixel Data	Section 10.4
	frames	N/A	N/A
	{framelist}	Retrieve Frames	Section 10.4
	rendered	Retrieve Rendered Frames	Section 10.4
	renderedmpr	**Retrieve Rendered MPR Volume Frames**	**Section 10.4**
	rendered3d	**Retrieve Rendered 3D Volume Frames**	**Section 10.4**
	thumbnail	Retrieve Frame Thumbnail	Section 10.4
	pixeldata	Retrieve Frame Pixel Data	Section 10.4
	instances	Search for Study Instances	Section 10.6
	series	Search for Series	Section 10.6
	{SeriesInstance}	N/A	N/A
	{instances}	Search for Instances	Section 10.6
	instances	Search for Instances	Section 10.6
	{BulkDataReference}	Retrieve Bulkdata	Section 10.4
…			

Add the following Section after Annex I:

X Rendered Volume Response Module

The Rendered Volume Response Module provides the user agent with a representation of the parameters applied by the origin server to generate the volumetric rendering.

The user agent may use this information to:

- inform the operator of the actual parameter values used, including both values specified in the request and values determined by the origin server (e.g., populate the user interface with parameters to aid in the interpretation of rendered content),
- serve as the basis for subsequent requests (e.g., to iteratively modify parameters to obtain a desired rendering outcome), or
- provide insight into the choices made by the origin server to select defaults and/or address errors when producing the rendering.

X.1 Response Message Body

Table X.1-1 defines the Attributes that are returned in a Rendered MPR Volume Resource or a Rendered 3D Volume Resource response message body.

Notes

1. These represent Query Parameters that may be specified by the user agent in Rendered MPR Volume Resources or Rendered 3D Volume Resources. See Section 8.3.5.3.
2. Anatomic orientation parameters (see Section 8.3.5.3.4) are converted to camera orientation parameters to facilitate fine grain adjustments in a subsequent request.

Table X.1-1. Rendered Volume Response Module Attributes

Attribute Name	Tag	Type	Attribute Description
Reformatting Operation Type	(0072,0510)	1	Reformatting operation to be applied to the Image Set.
Rendering Method	(0070,120D)	1	Specifies the display algorithm to be applied to the Volume Data.
Viewpoint Position	(0070,1603)	1	Position of the viewpoint in volume space.
Viewpoint LookAt Point	(0070,1604)	1	Point the viewpoint is looking at.
Viewpoint Up Direction	(0070,1605)	1	Vertical orientation of the view.
MPR Slab Thickness	(0070,1503)	1C	Required if Reformatting Operation Type (0072,0510) has a value of MPR and there is a specified thickness.
VOI LUT Function	(0028,1056)	1C	Required if Rendering Method (0070,120D) is not VOLUME_RENDERED.
Window Width	(0028,1051)	1C	Required if Rendering Method (0070,120D) is not VOLUME_RENDERED.
Window Center	(0028,1051)	1C	Required if Rendering Method (0070,120D) is not VOLUME_RENDERED.
Swivel Range	(0070,1A06)	1C	Required for SWIVEL animations.
Animation Step Size	(0070,1A05)	1C	Required for SWIVEL or CROSSCURVE animations.
Recommended Animation Rate	(0070,1A03)	1C	Required for video media types.

Modifications to PS3.17

Reword the heading for Section XXX as follows:

XXX. Volumetric Rendering ~~Presentation States~~ (Informative)

Add the following Section after Section XXX.6:

XXX.a Scope of Volumetric Rendering Web Service

Rendered Volume Resources enable a user agent to request a server-side 3D volumetric rendering. The user agent communicates the desired rendering by providing Query Parameters or a Volumetric Presentation State within the RESTful request. The origin server then resamples the Target Resource of DICOM instances into Volume Data, applies the provided parameters, and returns the representation in the requested Media Type.

Volumetric Rendering Query Parameters control basic functions that can be used independently, or in combination, to render a volume of Input Instances upon a GET request. Other advanced functions are enabled by referencing a Presentation State containing input instances or frames, rendering, presentation, graphic annotation, animation, cropping and segmentation parameters defined prior to a GET request. Basic and advanced functions are summarized in Table XXX.a-1

Table XXX.a-1. Basic and Advanced Web Services Functionality

Basic Functions Provided in Volumetric Rendering Web Services	Advanced Functions Available by also Referencing a Volumetric Presentation State
• Pan • Zoom • Windowing • Set Quality • Rotate • Animate • Set Render Method	• Display Color • Shading and Lighting • Crop • Compositing (e.g., fusion and blending) • Annotate • Perspective render projection • Render endoluminal view (e.g., fly through)

XXX.a.1 Volumetric Rendering Web Service Examples

XXX.a.1.1 MPR Rendering of a CT Series

A CT study is being reviewed on a web-based lightweight viewer. The viewer includes a hanging protocol that displays a coronal MPR as the optimal plane to view the anatomy of interest. The coronal view is presented as a thick slab MIP image to better present contrast enhanced vasculature. To obtain this image, the viewer submits a RESTful service request specifying a rendering mode, slab thickness, spacing, and media type. The origin server renders the referenced CT images based on the requested parameters and returns the result in the requested media type. The viewer presents the images.

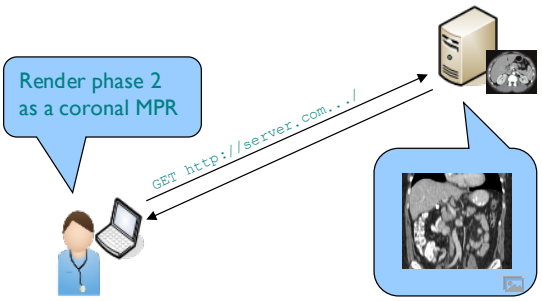


Figure XXX.a-1 MPR Rendering of a CT

XXX.a.1.1.1 Volumetric Rendering Web Service Pipeline

The user agent identifies input instances with geometric consistency, which are then assembled into volume data by the origin server. Algorithm and display parameters are applied to the volume data in order to achieve the requested presentation, and lastly, the representation is encoded into one or more images of the requested media type and returned in a response payload to the user agent.

Figure XXX.a-2 shows the rendering pipeline for a simple volume and how various parts of the request URL correspond to various rendering details. Details of each step are described in the subsections that follow.

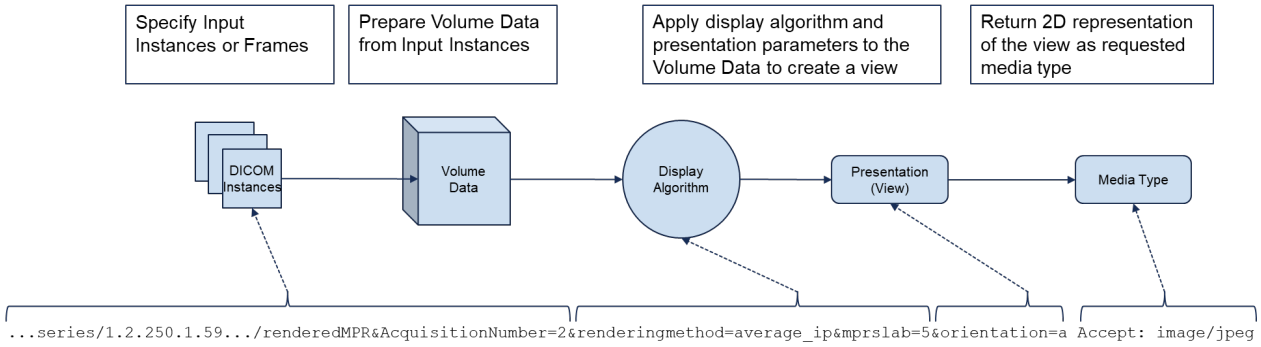


Figure XXX.a-2 Volumetric Rendering Web Service Rendering Pipeline for MPR Rendering of a CT

XXX.a.1.1.2 Specify Input Instances or Frames

Volumetric rendering applications require 2D slice data input. For the origin server to render the data as a volume, the input slices require a degree of consistency, such as a common patient frame of reference, pixel attributes (rows, columns, bit depth) and spatial alignment. Slices may possess Z-axis overlap and/or gaps. DICOM defines the requirements for collections of frames that make up Volumetric Source Information in the Presentation Input Type Volume Input Requirements in PS3.3, Section C.11.23.1.

In this example, three CT acquisitions through the liver are obtained, each corresponding to a contrast phase (arterial, portal-venous and venous). All images are in a single series of Legacy CT Image objects. The scanner used to acquire the images increments Acquisition Number (0020,0012) for each contrast phase in the series:

1 = arterial
2 = portal-venous
3 = venous

The user agent identifies the desired phase by requesting the Acquisition Number value “2”, corresponding to the portal-venous contrast phase. The origin server identifies the subset of instances

within the Target Resource having the requested Acquisition Number, determines that they meet the Presentation Input Type Volume Input Requirements, and proceeds to prepare the Volume Data.

XXX.a.1.1.3 Prepare Volume Data from Input Instances

Volumetric Source Information is used to prepare Volume Data. Simple Volume Data consists of a contiguous set of frames at a single point in time. A simple volume is also referred to as 3D, in which each of the three dimensions represent a spatial axis (x, y and z).

In this example, the origin server assembles the pixel data from the identified instances into a simple volume as depicted in Figure XXX.a-3.

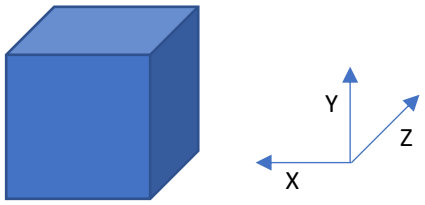


Figure XXX.a-3 Simple Volume Data

XXX.a.1.1.4 Apply Display Algorithm

The Volume Data is presented using a display algorithm, such as Volume Rendering (VR), Maximum Intensity Projection (MIP), and Multiplanar Planar Rendering (MPR).

In this example, the user agent requests a 5-millimeter thick, average intensity projection MPR. The origin server applies an “average_ip” algorithm, a method that projects the mean intensity of all interpolated samples in the path of each ray traced from the viewpoint to the plane of projection.

XXX.a.1.1.5 Apply Presentation Parameters

Presentation parameters define either:

- a fixed view
- an initial view and animation with optional parameters

In this example, the user agent requested an anterior view. Since an image media type, not a video media type, is requested in the Accept header field, and there is only one volume, the origin server creates a view of a fixed coronal orientation at a default location within the volume.

XXX.a.1.1.6 Return 2D Representation

In the last step of the pipeline, the rendered view is encoded using an Acceptable Media Type and returned in the response payload.

In this example, the user agent requests “image/jpeg” in the Accept header field. In response, the origin server returns a representation of the MPR as a single frame jpeg image.

XXX.a.1.2 3D MIP Rendering of an Enhanced MR Instance

A temporal MRI study (consisting of 5 Dynamic Contrast Enhanced phases of the breast) is being reviewed on a web-based lightweight viewer. The viewer includes a hanging protocol that displays a 3D MIP. To obtain the 3D MIP, the viewer submits a RESTful service request specifying the Instances to be rendered, rendering mode, orientation, animation and media type. The origin server renders the referenced MR images based on the requested parameters and returns the result in the requested media type. The viewer presents the images.

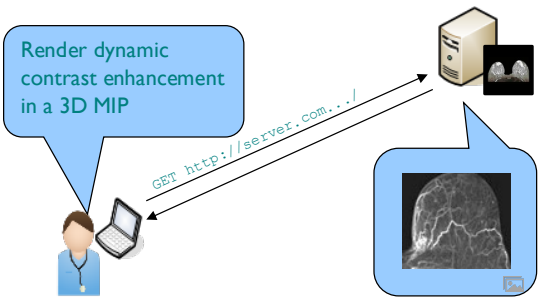


Figure XXX.a-4 MIP Rendering of an MR

XXX.a.1.2.1 Volumetric Rendering Web Service Pipeline

Figure XXX.a-2 shows the rendering pipeline for temporal volumes and how various parts of the request URL correspond to various rendering details. Details of each step are described in the subsections that follow. For brevity, only 2 volumes are shown.

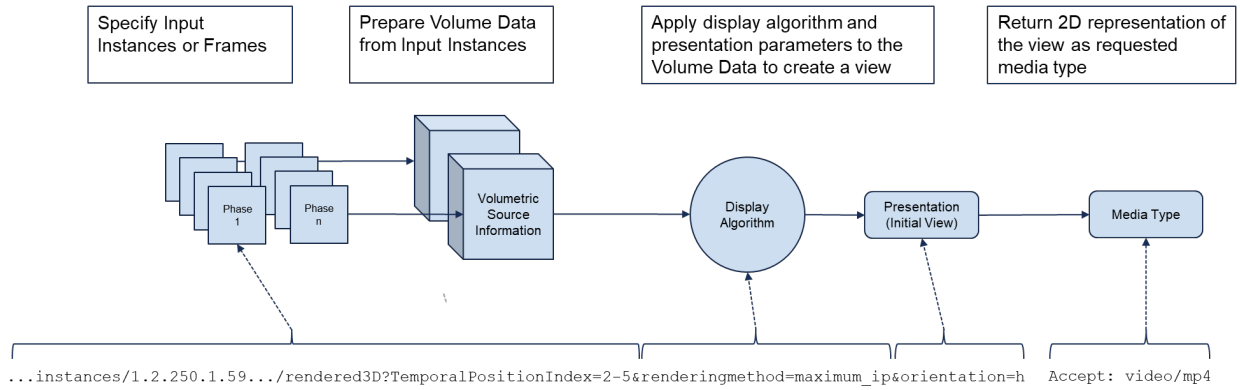


Figure XXX.a-5 Volumetric Rendering Web Service Rendering Pipeline for MIP Rendering of an MR

XXX.a.1.2.2 Specify Input Instances or Frames

In this example, the first phase is non-contrast, phases 2-5 are contrast enhanced. All phases are encoded in a single Enhanced MR object. Phases are identified by the Temporal Position Index (0020,0100).

The user agent identifies the desired phases by requesting the Temporal Position Index values “2-5” corresponding to the contrast enhanced phases. The origin server identifies the frames within the Target Resource having the requested Temporal Position Index, determines that they meet the Presentation Input Type Volume Input Requirements, and proceeds to prepare the Volume Data.

XXX.a.1.2.3 Prepare Volume Data from Input Instances

Multi-volume data consists of two or more simple volumes that are related and rendered simultaneously. Each time point is represented as a simple volume that meets the Volume Input Requirements.

In this example, the origin server assembles the pixel data of the matching frames into four simple volumes, one for each timepoint, as depicted in Figure XXX.a-3.

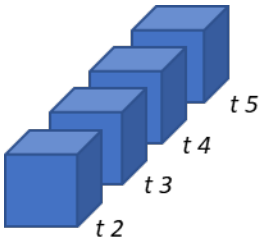


Figure XXX.a-6 Multi Volume Data

XXX.a.1.2.4 Apply Display Algorithm

In this example, the user agent requests a 3D MIP. The origin server applies a “maximum_ip” algorithm, a method that projects each volume with the maximum intensity of the samples that falls in the path of each ray traced from the viewpoint to the plane of projection.

XXX.a.1.2.5 Apply Presentation Parameters

In this example, the user agent requested a top-down view. As a video was requested, and no animation parameters were provided to specify the rotation of the 3D volumes, the origin server chooses not to apply any spatial animation. Instead, it applies a temporal animation, displaying each volume sequentially at a frame rate of 1fps.

XXX.a.1.2.6 Returned Images

In this example, the user agent requests video in the Accept header field. In response, the origin server returns a representation of the temporal MIP as a mpeg video.

XXX.b Converting MPR Orientation to Viewpoint Attributes in Volumetric Rendering Web Services

The Rendered 3D and Rendered MPR camera orientation parameters for Volumetric Rendering web services, such as the Volume Rendering Volumetric Presentation State IOD, specify orientation from the perspective of a camera in the Volumetric Presentation State Reference Coordinate System (VPS-RCS) with three parameters consisting of:

- “viewpointposition”, a point,
- "viewpointlookat", a point, and
- “viewpointup”, a vector.

Conversely, the Planar MPR Volumetric Presentation State IOD specifies the MPR slab orientation as a direction cosine (x,y,z), in the MPR View Width Direction (0070,1507) and MPR View Height Direction (0070,1511) attributes.

MPR slab orientation attributes can be converted to camera attributes as follows:

`viewpointlookat` = $T_{xyz} + X_{xyz} * W / 2 + Y_{xyz} * H / 2$

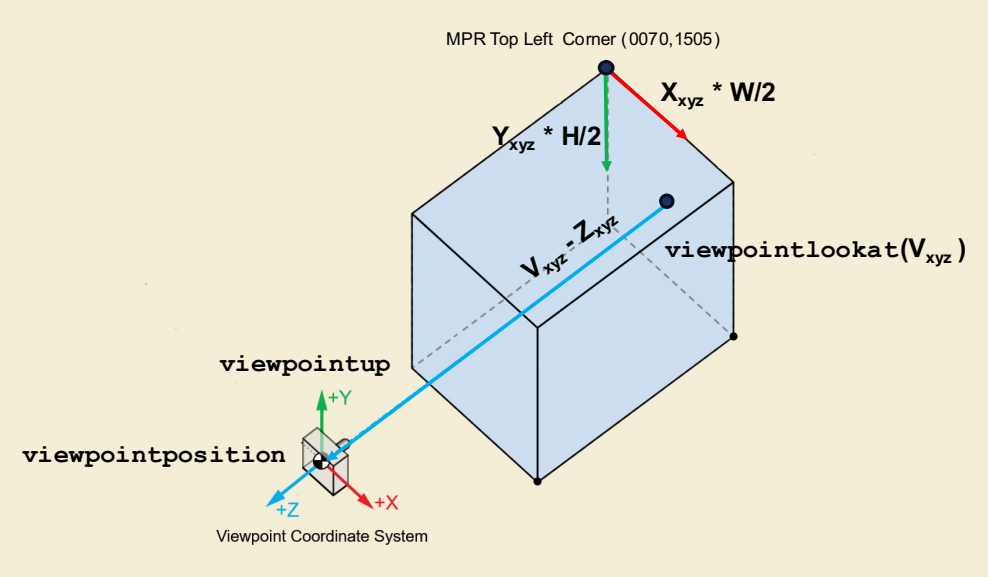
`viewpointposition` = $V_{xyz} - Z_{xyz}$

`viewpointup` = Y_{xyz}

Where:

T_{xyz} = coordinates of the MPR Top Left-Hand Corner (0070,1505) in mm
X_{xyz} = values from the direction cosine of the MPR View Width Direction (0070,1507)
Y_{xyz} = values from the direction cosine of the MPR View Height Direction (0070,1511)
Z_{xyz} = the vector cross products of X_{xyz} and Y_{xyz}

673 W = MPR View Width (0070,1508) in mm
674 H = MPR View Height (0070,1512) in mm
675 V_{xyz} = coordinates of the `viewpointlookat` point
676



677
678 **Figure XXX.c-1 Converting MPR Orientation to Viewpoint Attributes**