WEB SERVICES FOR VOLUMETRIC RENDERING
WG-27
Final Text

SCOPE

Introduces

- Web services for server-side volumetric rendering

Usage

- A web service client can request a rendered result by provide rendering parameters and/or a Volumetric Presentation State

GUIDING PRINCIPLES

- Focus on the most common rendering patterns

- Derive parameters from existing Volumetric Presentation State attributes

- Keep Volumetric Presentation State behaviors consistent with current Part 18 `/rendered`

- Minimize client burden; can omit detailed parameters, leaving them to the servers' discretion

- Allow servers latitude to define and apply default behaviors (i.e., when in doubt, let the server decide)

- State-less (client makes no assumptions about the server …but server may cache the Volume for performance)

- Target degree of rendering consistency similar to Volumetric Presentation State (PS17 XXX.1)

- Utilize the same Volume Input Requirements specified for Volumetric Presentation State (PS3 C.11.23.1)

WEB CLIENTS

Basic Functions

Available in Query Parameters:

- Pan
- Zoom
- Windowing
- Set Quality
- Rotate
- Animate
- Set Render Method

Advanced Functions

Available by referencing a Volumetric Presentation State:

- Display Color
- Shading and Lighting
- Crop
- Compositing (i.e., fusion and blending)
- Annotate
- Render projection or orthographic view
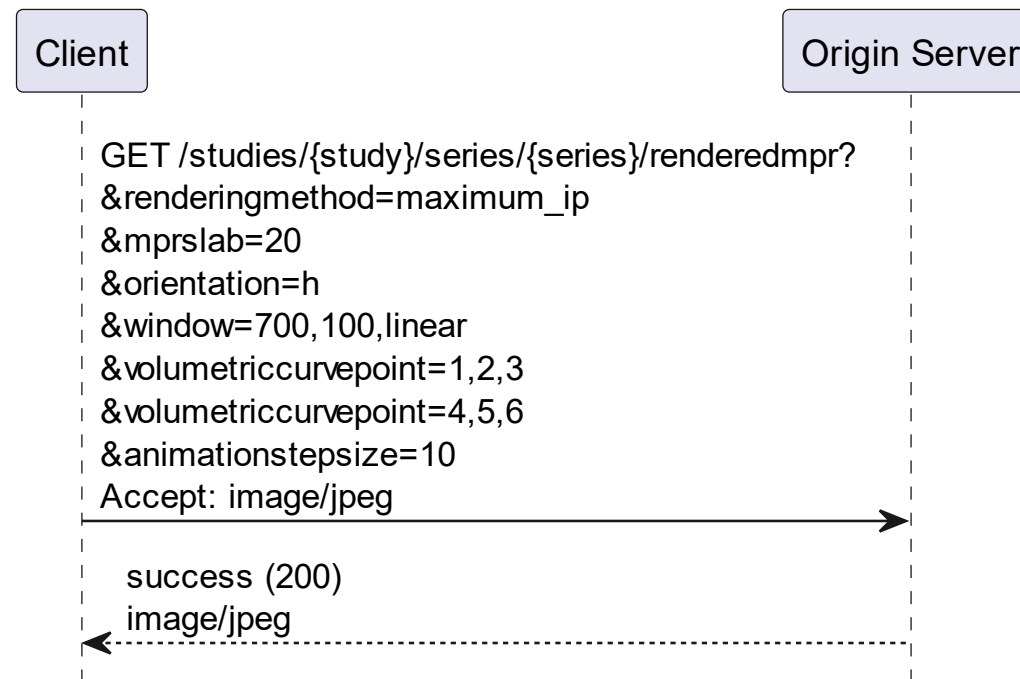- Render endoluminal view (i.e., fly through)

WEB SERVICES BASIC USE CASE

- Original 2D CT image slices are reviewed on a web-based lightweight viewer.

- The viewer includes a hanging protocol that displays thick slab MIP images based on the result of a RESTful service request.

- The RESTful service request specifies a pre-identified rendering mode, slab thickness, spacing, and returned media type.
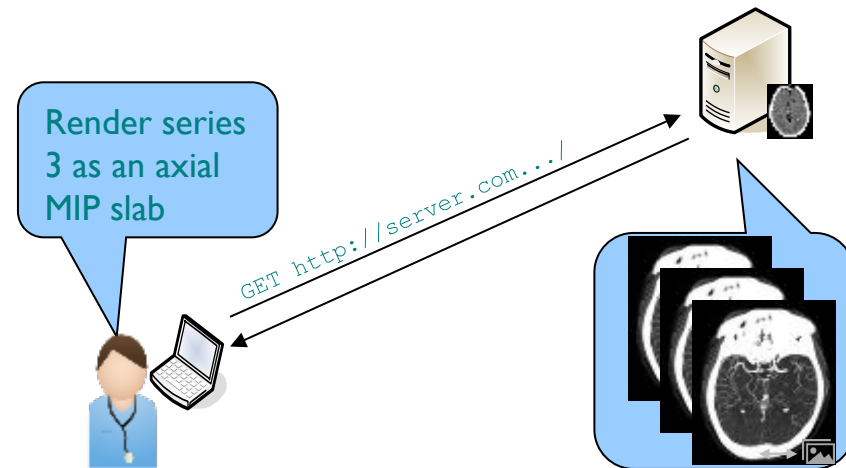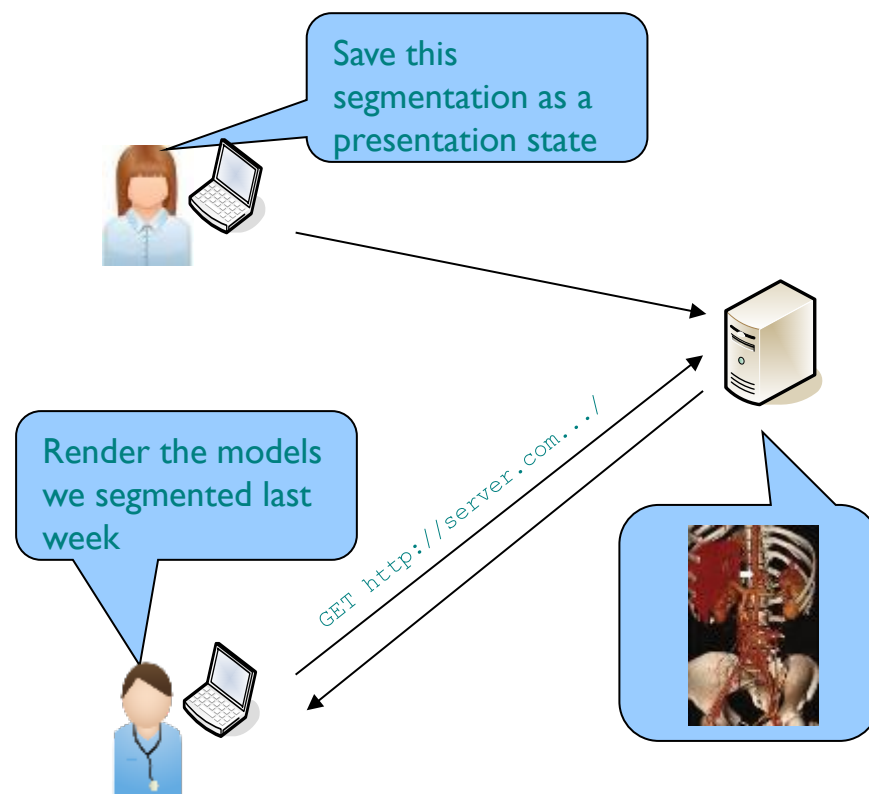
WEB SERVICES BASIC USE CASE

Render a Thick Slab MPR from a Series Target Resource

```
  Client                                    Origin Server
    │                                            │
    │ GET /studies/{study}/series/{series}/renderedmpr?
    │ &renderingmethod=maximum_ip                │
    │ &mprslab=20                                │
    │ &orientation=h                             │
    │ &window=700,100,linear                     │
    │ &volumetriccurvepoint=1,2,3                │
    │ &volumetriccurvepoint=4,5,6                │
    │ &animationstepsize=10                      │
    │ Accept: image/jpeg                         │
    │───────────────────────────────────────────►│
    │                                            │
    │  success (200)                             │
    │  image/jpeg                                │
    │◄ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─│
    │                                            │
```
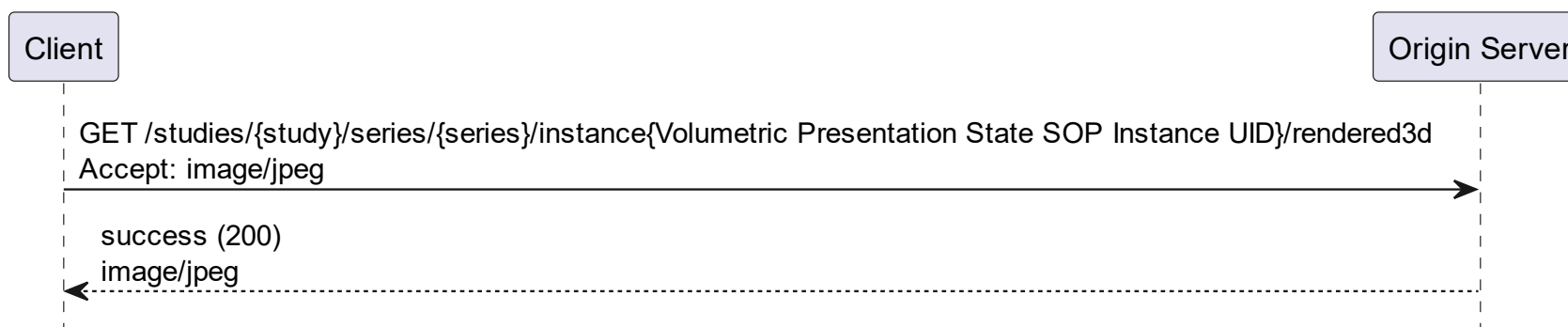
WEB SERVICE USING VOLUMETRIC PRESENTATION STATE

- A prospective liver donor is referred for a CT angiogram to assess their hepatic blood supply.

- A technologist segments the hepatic vein, portal vein and hepatic arteries in volumetric models that are saved as a DICOM Volumetric Presentation State.

- The surgeon selects the presentation state containing the rendered models of the anatomy of interest.

- The viewer submits a web service request referencing the presentation state.

WEB SERVICES ADVANCED USE CASE

Render a Volume Rendering Volumetric Presentation State Target Resource

RELATIONSHIP OF WEB SERVICES TO PRESENTATION STATES

- Volumetric Presentation States (supplements 156 and 190) save rendering parameters, segmentations and compositing, performed during post-processing of a specific patient study.

Modality — Post-Processing (server or workstation) — PACS — Render saved Presentation State
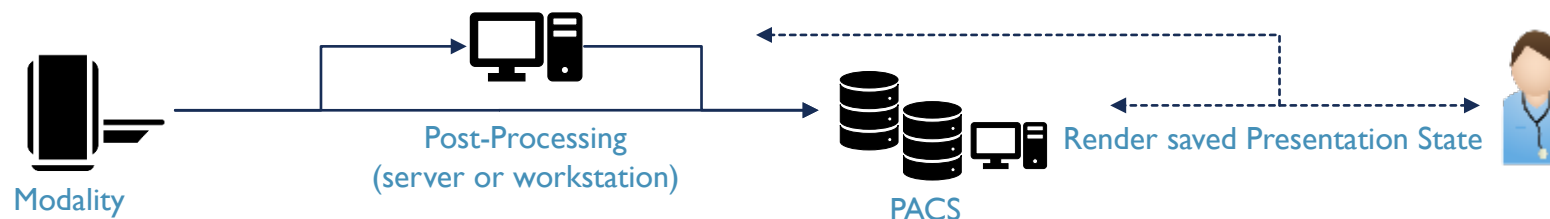
- Volumetric Rendering services render volumes based on parameters that are specified in the API request or in a Volumetric Presentation State target resource.

Rendering Server

Modality — PACS

Render based on Query parameters
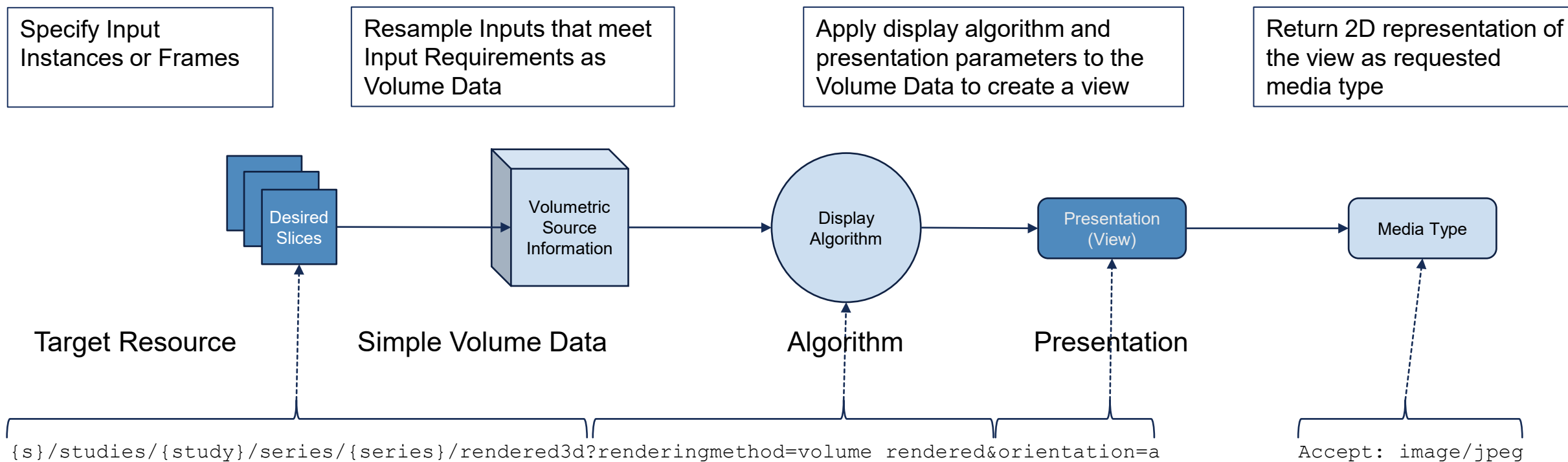or
Render a saved Presentation State
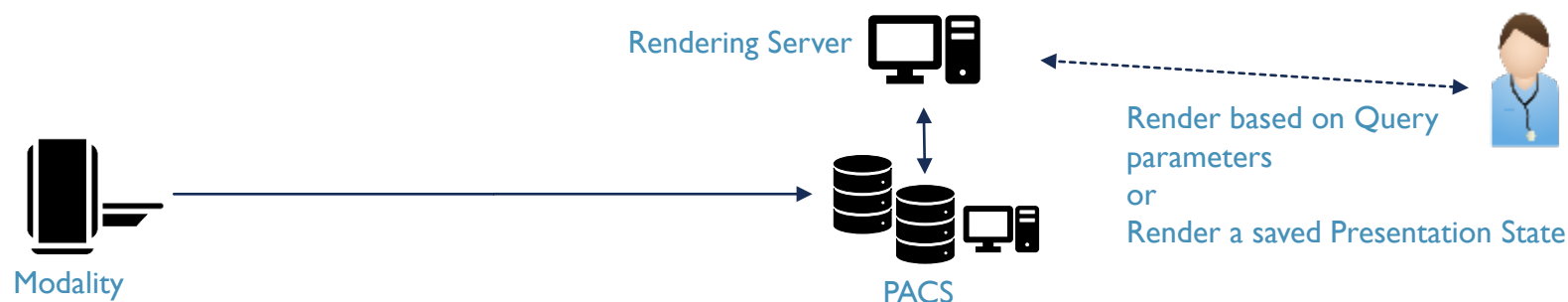
WEB SERVICES QUERY PARAMETERS

- Derived from existing Volumetric Presentation State attributes

- Used to control image set inputs, algorithm and presentation

- When Query Parameters are omitted, the Origin Server is expected to determine an appropriate value, or use a reasonable default

- Query Parameters (except orientation) do **not** override behavior established in a Volumetric Presentation State
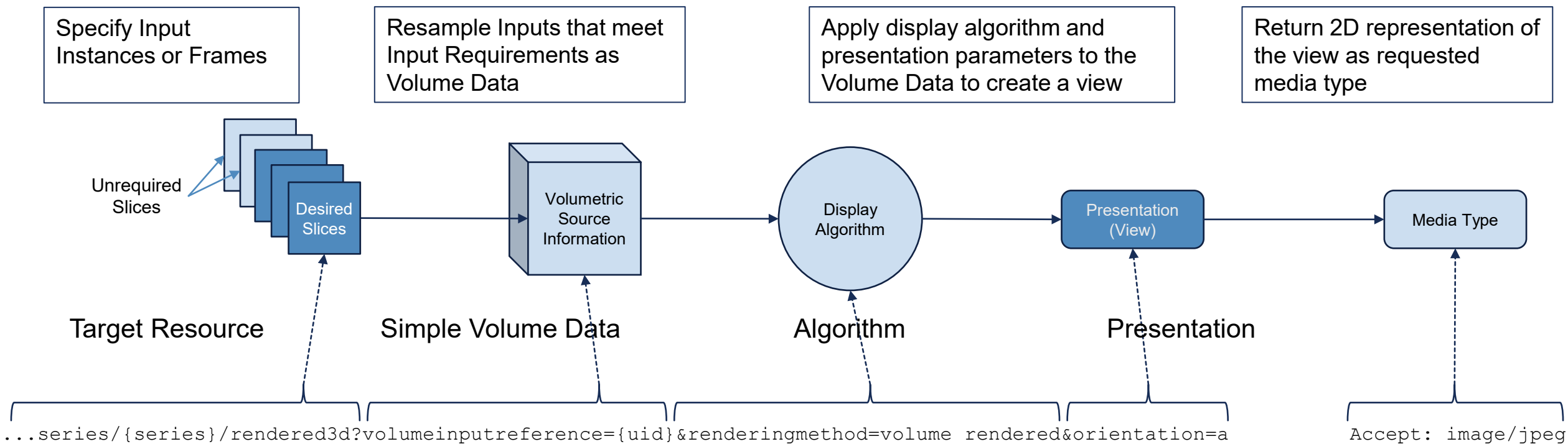
WEB SERVICES RENDERING PIPELINE

SIMPLE VOLUME PIPELINE

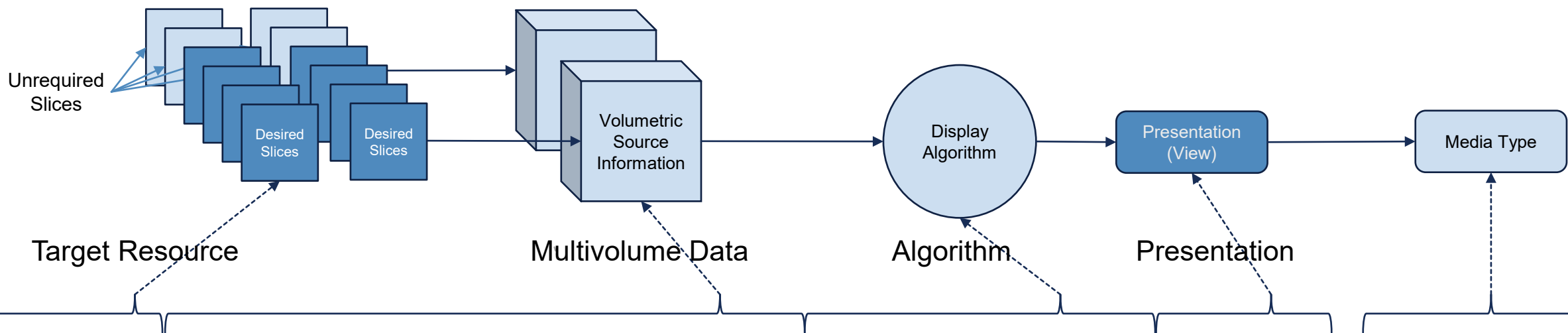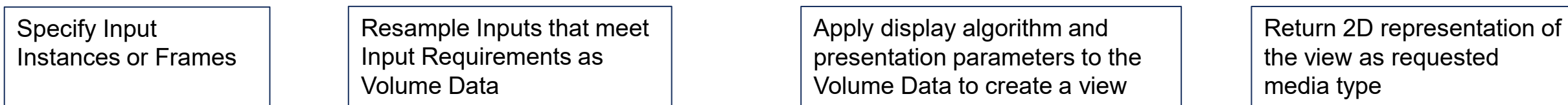A set of frames that meets Volume Input Requirements (PS3 C.11.23.1)

Specify Input Instances or Frames	Resample Inputs that meet Input Requirements as Volume Data	Apply display algorithm and presentation parameters to the Volume Data to create a view	Return 2D representation of the view as requested media type

Desired Slices → Volumetric Source Information → Display Algorithm → Presentation (View) → Media Type

Target Resource   **Simple Volume Data**   **Algorithm**   **Presentation**

```
{s}/studies/{study}/series/{series}/rendered3d?renderingmethod=volume_rendered&orientation=a        Accept: image/jpeg
```

SIMPLE VOLUME PIPELINE

A set of frames that requires refinement to meet Volume Input Requirements

Specify Input Instances or Frames

Resample Inputs that meet Input Requirements as Volume Data

Apply display algorithm and presentation parameters to the Volume Data to create a view

Return 2D representation of the view as requested media type

Unrequired Slices

Desired Slices

Volumetric Source Information

Display Algorithm

Presentation (View)

Media Type

Target Resource

Simple Volume Data

Algorithm

Presentation

```
...series/{series}/rendered3d?volumeinputreference={uid}&renderingmethod=volume_rendered&orientation=a
```

```
Accept: image/jpeg
```

MULTIVOLUME PIPELINE

A set of temporal frames that requires refinement to meet Volume Input Requirements

Specify Input Instances or Frames

Resample Inputs that meet Input Requirements as Volume Data

Apply display algorithm and presentation parameters to the Volume Data to create a view

Return 2D representation of the view as requested media type

Unrequired Slices

Desired Slices

Desired Slices

Volumetric Source Information

Display Algorithm

Presentation (View)

Media Type

Target Resource

Multivolume Data

Algorithm

Presentation

`.../renderedmpr?FrameContentSequence.TemporalPositionIndex=140-260&renderingmethod=maximum_ip&orientation=a`   `Accept: video/mp4`

WEB SERVICES KEY TERMS

- **Volume Input Requirements**: constraints on the input instances or frames identified as input to Volumetric Rendering. See PS3.3 C.11.23.1 Presentation Input Type Volume Input Requirements for a detailed definition. Only instances or frames conforming to Volume Input Requirements can be rendered

- **Volume Data**: Instances or frames conforming to Volume Input Requirements are resampled into Volume Data, represented by a set of parallel XY planes whose positions are relative to each other, arranged in a cartesian voxel grid.
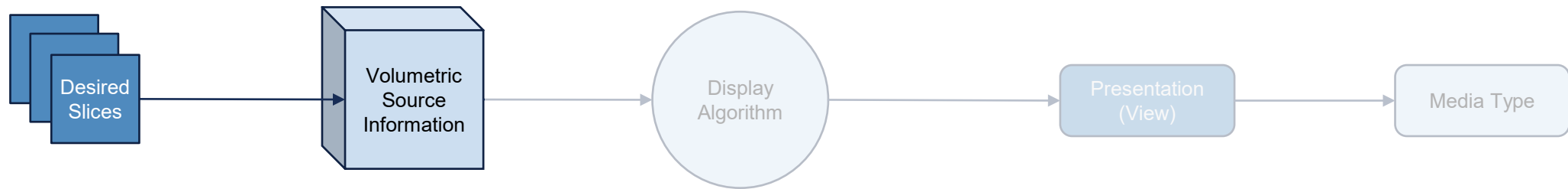
SPECIFY INPUTS & VOLUME DEFINITION

WEB SERVICES TYPES OF INPUT

Source IOD Type	Target Resource	Target Description	Resource URI
Multi-frame	Instance	An instance containing only a set of frames that satisfy Volume Input Requirements.	`/studies/{study}/series/{series}/instances/{instance}`
Multi-frame	Instance	An instance containing a set of frames with a subset that satisfies Volume Input Requirements. The subset is explicitly identified by the user agent.	`/studies/{study}/series/{series}/instances/{instance}/frames/{frames}`
Multi-frame	Instance	An instance containing a set of frames with a subset that satisfies Volume Input Requirements. The subset is identified by the origin server based on characteristics provided by the user agent.	`/studies/{study}/series/{series}/instances/{instance}`
Volumetric Presentation State	Instance	An instance containing references (in the Volumetric Presentation Input Set Sequence) to a set of frames that satisfy the Volume Input Requirements	`/studies/{study}/series/{series}/instances/{instance}`
Single Frame	Series	A series containing only a set of instances that satisfy Volume Input Requirements.	`/studies/{study}/series/{series}`
Single Frame	Series	A series containing a set of instances with a subset that satisfies Volume Input Requirements. The subset is identified by the origin server based on characteristics provided by the user agent.	`/studies/{study}/series/{series}`

WEB SERVICES RELATED PARAMETERS

Parameters to specify input frames within the Target Resource that meet Volume Input Requirements (PS3 C.11.23.1)

- `volumeinputreference`: an image having characteristics of what is to be rendered (i.e., render images like this)

- *Attribute Matching*: specifies common Attribute/Value pair characteristics of the Volume Data (PS3.18 8.3.4.1)

WEB SERVICES EXAMPLES

Target Resource	Parameter	Volume Type
Legacy Instances in 1 Series		
/studies/{uid}/series/{uid}/		Simple
Multiple Phases, each in its own series		
/studies/{uid}/	CardiacRRIntervalSpecified=140-260 *defines image set, server determines volume grouping	Multi-volume
Legacy Series Containing Multiple Phases		
/studies/{uid}/series/{uid}/	AcquisitionNumber=1-3 *defines image set, server determines volume grouping	Multi-volume
One Phase within a Classic Series Containing Multiple Phases		
/studies/{uid}/series/{uid}/	AcquisitionNumber=2	Simple
One Stack within an Enhanced Instance Containing Multiple Stacks		
/studies/{uid}/series/{uid}/instance{uid}/	StackId={n}	Simple

WEB SERVICES USE CASE: MULTIPHASE LIVER

- 3 scans through the liver are obtained , each corresponding to a contrast phase (arterial, portal-venous and venous)

- All images are in a single series of Classic CT Image objects.

- The scanner used to acquire the images increments Acquisition Number (0020,0012) for each "pass" through the liver:

  - 1 = arterial

  - 2 = portal-venous

  - 3 = venous

- Example:
  ```
  .../series/{series}/renderedmpr?AcquisitionNumber=1-3
  &renderingmethod=maximum_ip
  &orientation=a
  &animationrate=10
  Accept: video/mp4
  ```
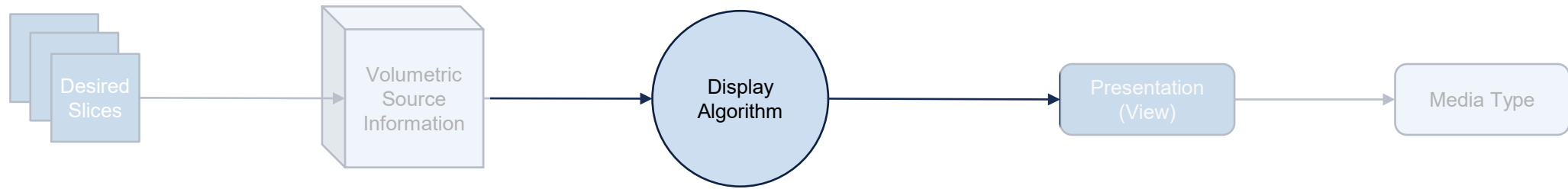
ALGORITHM

WEB SERVICES RELATED PARAMETERS & RESOURCES

Control the rendering algorithm applied to the Volume Data

New Resources

- /rendered3D: resource specifies 3D volumetric rendering

- /renderedMPR: resource specifies planar reformatting

New Parameters

- `renderingmethod`: the display algorithm, i.e., volume rendered, MIP, MINip, average

- `mprslab`: MPR slab thickness
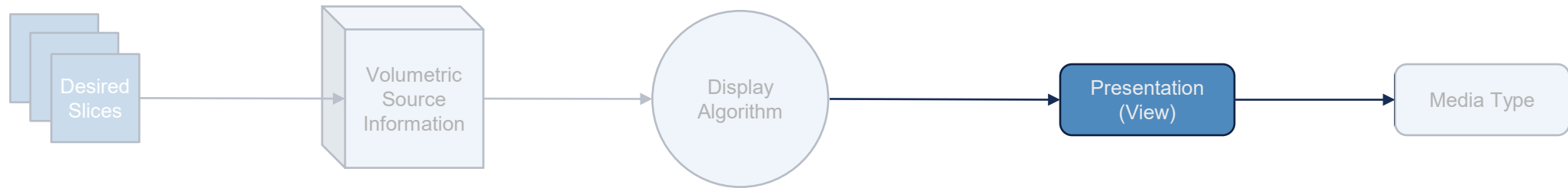
WEB SERVICES RELATED PARAMETERS & RESOURCES

Control the rendering algorithm applied to the Volume Data

Existing Parameters (see PS3.18, Section 8.3.5.1.4)

- *Windowing*: control window/center of MIP, MINip, average renderings

WEB SERVICES EXAMPLES

|	Rendering Type	Rendering Method	VOI	Slab
3D VR	/rendered3D			
3D MIP	/rendered3D	=maximum_ip	window, center, function	
Planar reformat (nominal thickness)	/renderedMPR	=average_ip	window, center, function	
5mm slab, average	/renderedMPR	=average_ip	window, center, function	mprslab=5
25mm slab, MIP	/renderedMPR	=maximum_ip	window, center, function	mprslab=25
2mm slab, minIP	/renderedMPR	=minimum_ip	window, center, function	mprslab=2
10mm slab, VR	/renderedMPR			mprslab=10

PRESENTATION

WEB SERVICES RELATED PARAMETERS

- `viewport`: control scaling (i.e., Render Field of View) of the rendered 2D image or video

- Two mutually exclusive options to determine the initial orientation of the resampled Volume Data:

  - The "`orientation`" parameter roughly establishes the standard anatomic position of the patient as viewed by the camera, and

  - Camera orientation parameters ("`viewpointposition`", "`viewpointlookat`", or "`viewpointup`") precisely establish the camera position and direction as it views the patient. See C.11.30.1 in PS3.3
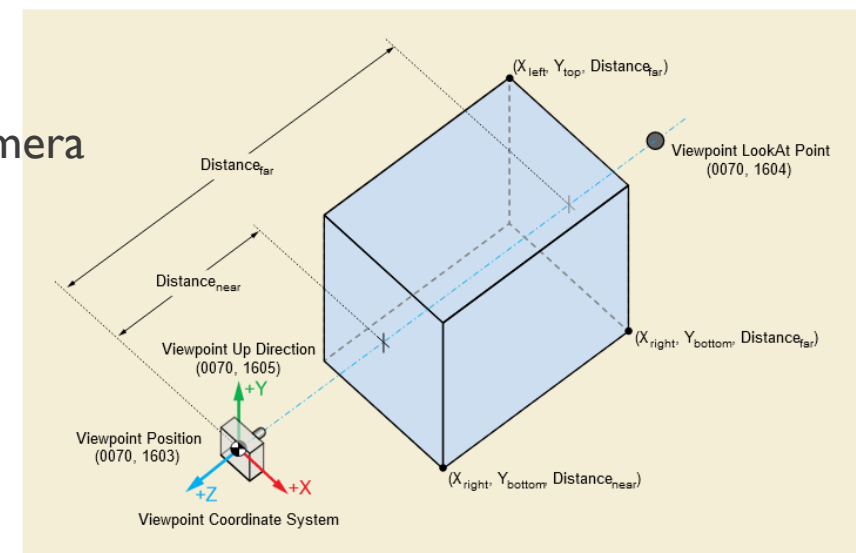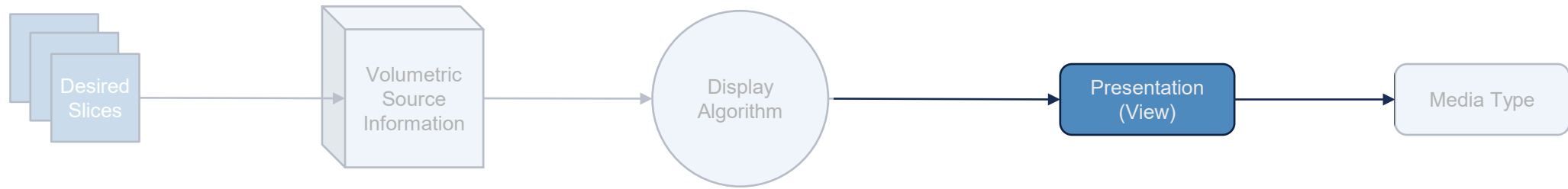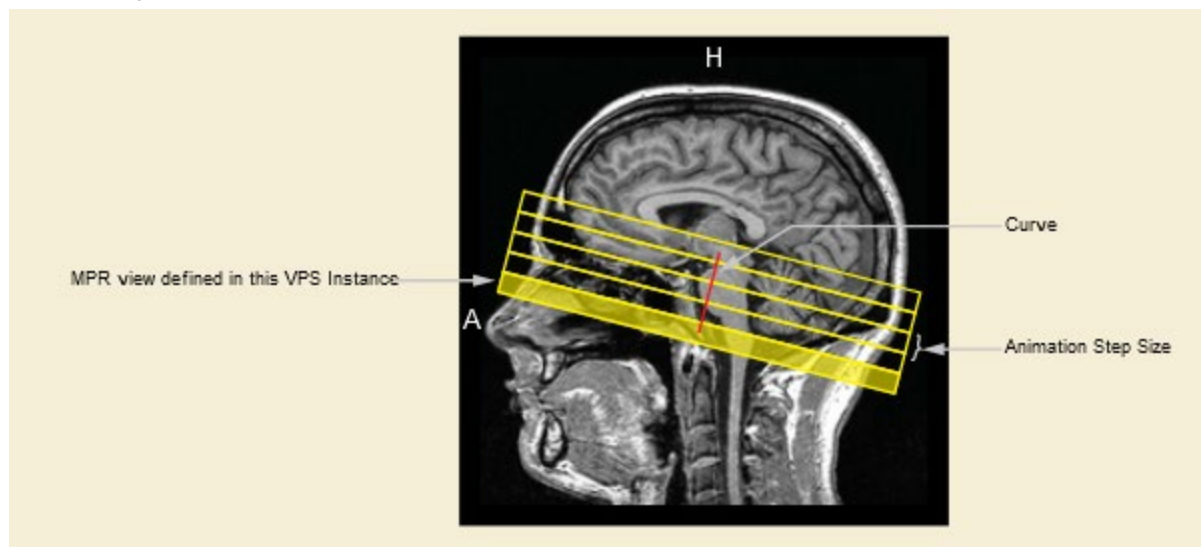
ANIMATION

RELATED PARAMETERS

Initial frame is established by orientation/viewpoint parameters. The animation parameters dictate subsequent frames. The origin server determines initial phase displayed for multivolume temporal data.

- `swivelrange`: angular range over which a rendered volume rotates around the swivel axis.

- `volumetriccurvepoint`: coordinates of points of the animation curve.

- `animationstepsize`: distance between animation steps (degrees between steps in a swivel, or mm between steps along an animation curve). This is identical to animation in a Volumetric Presentation State.

See PS3.17 XXX.3.4.1

WEB SERVICES EXAMPLE

	Media Type	Rendering Type	Animation	Direction	Rate
Single Volume	Image	/rendered3D /renderedMPR	none		
	Video	/rendered3D	Rotating 3D	swivel	animationrate steps
	Video	/renderedMPR	Planar stack	volumetriccurvepoints	animationrate steps
	Video	/renderedMPR	Radial batch stack	volumetriccurvepoints	animationrate steps
Temporal Volume	Video	/rendered3D /renderedMPR	Beating heart		animationrate
	Video	/rendered3D	Rotating + Beating heart	swivel	animationrate steps
	Video	/renderedMPR	Planar stack + Beating heart	volumetriccurvepoints	animationrate steps
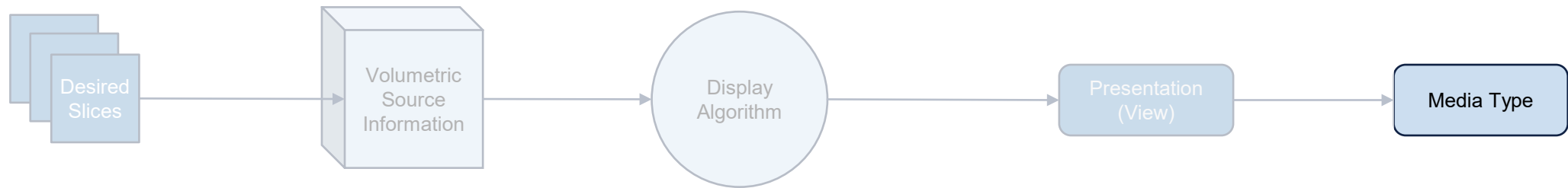
RETURN IMAGE

MEDIA TYPES

Volumetric Presentation	Resource Category (PS3.18 Table 8.7.2-1)	Return Media Type (PS3.18 Table 8.7.4-1)	Example
Static	Single Frame Image	image/jpeg image/gif image/png image/jp2 image/jph	Lateral projection of a 3D ankle
Animated	Multi-Frame Image	image/gif	Rotating 3D ankle
Animated	Video	video/mpeg video/mp4 video/H265	Rotating 3D ankle

RETURNING RENDERING METADATA

Use Case

A client wants to request a "default" volume rendering from the origin server, but expects its user to want to modify parameters for updated renderings.

1. A client requests a volume rendering and provides no query parameters.
2. The origin server returns the rendering based on default values that it chose to apply.
3. The client repeats the request, adding the `volumetricmetadata` parameter.
4. The origin server returns a response module containing all the applied parameters and values.
5. The client modifies some parameter values and makes a new volume rendering request including all the parameters.