Digital Imaging and Communications in Medicine (DICOM)

Supplement 240: Height Map Segmentation and Revised Ophthalmic OCT En Face Image

Prepared by:

DICOM Standards Committee, Working Group 09 (Ophthalmology)

1300 N. 17th Street, Suite 900

Rosslyn, Virginia 22209 USA

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Scope and Field of Application

HEIGHT MAP SEGMENTATION

This Supplement introduces a new Height Map Segmentation IOD and SOP Class.

heightmap (computer graphics) A two-dimensional raster image used to store surface elevations that can later be applied to a three-dimensional object. *https://en.wiktionary.org/wiki/heightmap*

In its DICOM use, height map is a type of segmentation using a 2D set of pixels to identify a surface in the 3D volume of a referenced multi-frame image. In the degenerate case, it can identify the intersection of a surface with a single image plane, i.e., a 1D raster for a 2D object.

The Height Map Segmentation IOD follows the current enhanced multi-frame image data architecture. For data management purposes, e.g., with Media Exchange, Height Map Segmentation SOP Instances may be treated similarly to other segmentation images. While intended to be broadly applicable for a variety of medical imaging domains, the initial use case is in ophthalmic tomography (OPT) for representing segmentation of retinal layers.

Further description of Height Map Segmentation is found in the proposed informative annex to PS3.17.

OPHTHALMIC OCT EN FACE IMAGE

This Supplement also revises the current Ophthalmic Optical Coherence Tomography En Face Image IOD, which had required use of Surface Segmentation SOP Instances to specify a retinal layer, to allow use of any type of segmentation SOP Instances, including Height Map Segmentation or other (including future) SOP Classes.

The reference to the segmentation object in the En Face Image object enables traceability of the processing steps that produced the image. It is not necessarily the case that a receiving application could reproduce the En Face Image from the original source Ophthalmic Tomography Image(s) and the referenced segmentation object(s).

DICOM PS 3.3: Information Object Definitions

Add Height Map Segmentation IOD to Section A.1.4 summary table

A.1.4 Overview of the Composite IOD Module Content

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Table A.1-1e. Composite Information Object Modules Overview - More Images

IODs / Module	…	Hgt Map Seg
Patient		**M**
Clinical Trial Subject		**U**
General Study		**M**
Patient Study		**U**
Clinical Trial Study		**U**
General Series		**M**
Clinical Trial Series		**U**
Segmentation Series		**M**
Intravascular OCT Series		
Frame of Reference		**M**
Synchronization		
Cardiac Synchronization		
General Equipment		**M**
Enhanced General Equipment		**M**
Acquisition		
Multi-Resolution Pyramid		
General Image		**M**
General Reference		**U**
Microscope Slide Layer Tile Organization		
Image Pixel		
Floating Point Image Pixel		**M**
Supplemental Palette Color Lookup Table		
Enhanced Contrast/Bolus		

Multi-frame Functional Groups		**M**
Multi-frame Dimension		**M**
Device		
Specimen		
Intravascular OCT Image		
Intravascular OCT Acquisition Parameters		
Intravascular OCT Processing Parameters		
Intravascular Image Acquisition Parameters		
Segmentation Image		
Height Map Segmentation Image		**M**
Common Instance Reference		**M**
Acquisition Context		
ICC Profile		**U**
SOP Common		**M**
Frame Extraction		**C**

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Revise Ophthalmic OCT En Face Image IOD description

A.83 OPHTHALMIC OPTICAL COHERENCE TOMOGRAPHY EN FACE IMAGE IOD

This Section defines an Information Object to be used with several types of en face images that are derived from volumetric images obtained using **optical coherence tomography (**OCT**)** technology. En face images may be based upon structural OCT volumes and ~~**surface mesh**~~ **segmentation** information only**,** or structural OCT volumes, ~~**surface mesh**~~ **segmentation** information and angiographic flow volume information.

Note This IOD has been modified with non-backward compatible changes relative to the definition in PS3.3-2024c and prior editions, which was determined to have significant deficiencies for implementation.

Add new section for Height Map Segmentation IOD

A.91 HEIGHT MAP SEGMENTATION IOD

A.91.1 Height Map Segmentation IOD Description

The Height Map Segmentation Information Object Definition (IOD) specifies the location of one or more layer surfaces within a 3D volume, e.g., for retinal or epithelial layers. For each coordinate of the reference plane, each layer has at most one surface point at a distance perpendicular to the reference plane. However, not all coordinates of the reference plane might have a corresponding distance specified for any particular layer.

Each frame of a Height Map Segmentation SOP Instance corresponds to a segmented layer within a referenced derivation image. Each row in a Height Map Segmentation frame corresponds to a single frame in a derivation image, and the pixel values in a row represent the height map data for a segmented layer as it intersects the derivation image frame. The Height Map Segmentation SOP Instance does not include the full set of acquisition parameters of the derivation image and frames, e.g., Plane Orientation, or Plane Position. An application rendering or processing the segmentation may need to access the referenced derivation image for such information.

Note The frames of the derivation image may not form a regularly spaced voxel set (see concepts in CID 4272 “OPT Scan Pattern Type”). The image rows in the segmentation frame pixel set follow the orientations of the derivation image frames, and thus rendering a frame of the height map segmentation in Cartesian 3D space may require obtaining the orientation and position of each derivation image frame.

A.91.2 Height Map Segmentation IOD Entity-Relationship Model

The Height Map Segmentation IOD uses the E-R Model specified in Section A.1.2, with only the Image IE below the Series IE.

A.91.3 Height Map Segmentation IOD Module Table

Table A.91-1 lists the Modules that make up the Height Map Segmentation IOD.

Table A.91-1. Height Map Segmentation IOD Modules

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	Clinical Trial Subject	C.7.1.3	U
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
	Clinical Trial Study	C.7.2.3	U
Series	General Series	C.7.3.1	M

	Segmentation Series	C.8.20.1	M
	Clinical Trial Series	C.7.3.2	U
Frame of Reference	Frame of Reference	C.7.4.1	M
Equipment	General Equipment	C.7.5.1	M
	Enhanced General Equipment	C.7.5.2	M
Image	General Image	C.7.6.1	M
	Multi-frame Functional Groups	C.7.6.16	M
	Multi-frame Dimension	C.7.6.17	M
	Floating Point Image Pixel	C.7.6.24	M
	Height Map Segmentation Image	C.8.20.5	M
	ICC Profile	C.11.15	U
	SOP Common	C.12.1	M
	Common Instance Reference	C.12.2	M
	Frame Extraction	C.12.3	C - Required if the SOP Instance was created in response to a Frame-Level retrieve request
	General Reference	C.12.4	U

A.91.4 Height Map Segmentation IOD Constraints

A.91.4.1 Frame of Reference UID

Frame of Reference UID (0020,0052) in this SOP Instance shall have the same value as the Frame of Reference UID (0020,0052) of the SOP Instance(s) referenced in the Derivation Image Functional Group.

Note: The coordinate system associated with the Frame of Reference may be deformed (e.g., see Section A.52.4.3). The height map data is defined with respect to image frames within the identified Frame of Reference.

A.91.5 Height Map Segmentation Functional Groups

Table A.91-2 specifies the use of the Functional Group Macros used in the Multi-frame Functional Groups Module for the Height Map Segmentation IOD.

Table A.91-2. Height Map Segmentation Functional Group Macros

Functional Group Macro	Section	Usage
Pixel Measures	C.7.6.16.2.1	M
Frame Content	C.7.6.16.2.2	M - May not be used as a Shared Functional Group.
Plane Position (Patient)	C.7.6.16.2.3	C – Required if value of Rows is greater than 1, may be present otherwise
Plane Orientation (Patient)	C.7.6.16.2.4	C – Required if value of Rows is greater than 1, may be present otherwise
Referenced Image	C.7.6.16.2.5	U
Derivation Image	C.7.6.16.2.6	M
Real World Value Mapping	C.7.6.16.2.11	M
Segmentation	C.8.20.3.1	M

A.91.5.1 Height Map Segmentation Functional Groups Description

A.91.5.1.1 Derivation Image

The Derivation Image Functional Group shall identify one or more Image SOP Instances that are the source for the volumetric space to which the Height Map Segmentation frame applies. Referenced derivation images shall have the same Frame of Reference UID (0020,0052).

Each Item of the Derivation Image Functional Group shall specify a number of frames equal to the value of Rows (0028,0010) in the Height Map Segmentation SOP Instance. The Derivation Image Functional Group for a Height Map Segmentation frame with multiple rows shall enumerate the referenced frame for each row in Referenced Frame Number (0008,1160). Alternatively, if the Functional Group references a single derivation image with a number of frames equal to the number of Height Map Segmentation rows, the Referenced Frame Number (0008,1160) Attribute may be omitted, and the Height Map Segmentation rows shall correspond to the derivation image frames in their storage order in the pixel data.

The value of Purpose of Reference Code Sequence (0040,A170) in the Derivation Image Functional Group shall be (121322, DCM, "Source Image for Image Processing Operation"). The value of Derivation Code Sequence (0008,9215) shall be (113076, DCM, "Segmentation").

Note: The referenced derivation image is the source of the pixel/voxel matrix extent in which the Height Map Segmentation is defined. It might technically not be a source image from which the segmentation is derived, e.g., if both the referenced image and the segmentation are derived from a raw acquisition data set. Use of (121322, DCM, "Source Image for Image Processing Operation") is specified to maintain consistency with the Segmentation IOD (see Section A.51.5.1). Other source data SOP Instances can be identified in the Referenced Image Functional Group.

A.91.5.1.2 Pixel Measures

Pixel Spacing (0028,0030) in the Pixel Measures Functional Group specifies the real-world physical distance in the imaging target (patient) as row spacing and column spacing in mm (see Section C.7.6.16.2.1 and Section 10.7.1.3). The pixel spacing of the Height Map Segmentation is determined by the pixel measures of the referenced derivation image (see Figure A.91.5-1). As each height map row corresponds to a derivation image frame with the same number of columns, value 2 (column spacing) of Pixel Spacing (0028,0030) in the Height Map Segmentation will equal value 2 of Pixel Spacing (0028,0030) in the referenced derivation image.

Height Map Segmentation frames with more than one row correspond to a set of parallel derivation image frames, i.e., whose Image Orientation (Patient) (0020,0037) values are identical. As the height map frame is orthogonal to those derivation image frames, value 1 (row spacing) of Pixel Spacing (0028,0030) in the Height Map Segmentation will equal the spacing between derivation image frames, computed from differences in Image Position (Patient) (0020,0032) of the referenced derivation image frames.

Notes

1. As specified in Section 10.7.1.3, if there is only a single row in the Height Map Segmentation frames, the row spacing value may be zero.

2. Height Map Segmentation is defined only for cases where the rows of height map data correspond to the top rows of derivation image frames, and the columns of the Height Map Segmentation correspond to the frames of the derivation image. It is not defined for cases where the derivation image frames are parallel to the Height Map Segmentation frame, or for the 90 degree rotation with the Height Map Segmentation columns corresponding to the derivation image rows, or for the Height Map Segmentation to be aligned to the bottom of the derivation image frames.

3. The value of Spacing Between Slices (0018,0088) in the derivation image might be used to determine the row spacing of the Height Map Segmentation, but that Attribute is Type 1C in the Ophthalmic Tomography IOD, and

might not be present. Even if present, it would not be valid if decimated frames of the derivation image are referenced.

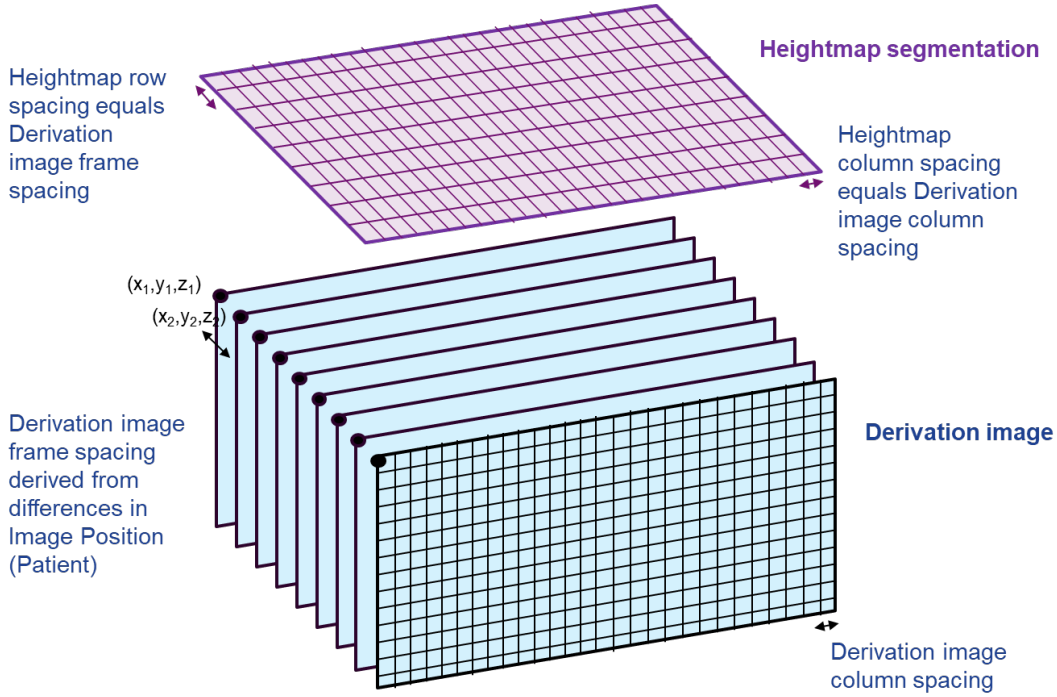

Figure A.91.5-1 – Height Map Pixel Spacing from Derivation Image Attributes

A.91.5.1.3 Plane Position and Plane Orientation

The Plane Position (Patient) and Plane Orientation (Patient) Functional Groups shall be present in a Height Map Segmentation with multiple rows. The values of Image Position (Patient) (0020,0032) and Image Orientation (Patient) (0020,0037) are derived from the values in the derivation image.

Note: The value of Image Position (Patient) (0020,0032) will be equal to the value of Image Position (Patient) (0020,0032) in the first referenced frame of the Derivation Image. The value of Image Orientation (Patient) (0020,0037) will have row direction cosines equal to the row direction cosines of the referenced derivation image, and column direction cosines equal to the cross product of the column direction cosines and row direction cosines of the referenced derivation image. If the coordinate system associated with the Frame of Reference is deformed (e.g., see Section A.52.4.3), then the orientation will be the nominal real world orientation.

Image Position (Patient) (0020,0032) and Image Orientation (Patient) (0020,0037) might not be present in the derivation image, in particular for non-volumetric (e.g., circular) scans, where the derivation image is located in space by reference to points on a localizer image rather than by Plane Position and Plane Orientation.

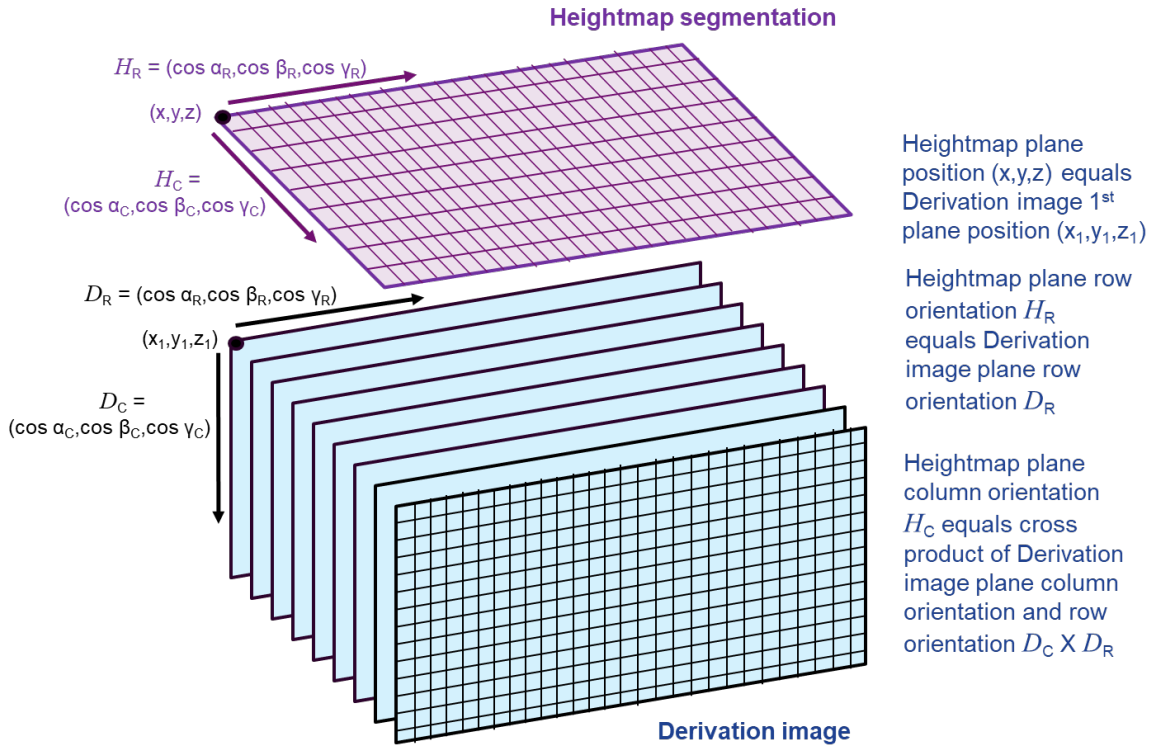

Figure A.91.5-2 – 2D Height Map Plane Position and Orientation from Derivation image Attributes

A.91.5.1.4 Real World Value Mapping

The Real World Value Mapping Functional Group shall provide the mapping of Height Map Segmentation pixel values to real world distance in the volume defined by the derivation image. Height Map values are floating point numbers representing vertical pixel distances with sub-pixel resolution in the pixel matrix of the derivation image. The value of Measurement Units Code Sequence (0040,08EA) shall be (mm, UCUM, “mm”). Values in the pixel padding range, i.e., between the values of Float Pixel Padding Value (0028,0122) and Float Pixel Padding Range Limit (0028,0124), shall not be mapped.

Note: The value of Real World Value Slope (0040,9225) will typically be equal to first value (row spacing) of the Pixel Spacing (0028,0030) Attribute in the Pixel Measures Functional Group of the referenced derivation image. If the coordinate system associated with the Frame of Reference is deformed (e.g., see Section A.52.4.3), then the value mapping will be the nominal real world distance.

The value of Real World Value First Value Mapped (0040,9216) or Double Float Real World Value First Value Mapped (0040,9214) will typically be 0. The value of Real World Value Last Value Mapped (0040,9211) or Double Float Real World Value Last Value Mapped (0040,9213) will typically be equal to the number of rows in the derivation image.

Update Segment Description Macro to allow Anterior-Posterior modifier

C.8.20.4.1 Segment Description Macro

250 Table C.8.20-4 specifies the Attributes of the Segment Description Macro.

Table C.8.20-4. Segment Description Macro Attributes

Attribute Name	Tag	Type	Attribute Description
Segment Number	(0062,0004)	1	Identification number of the segment. The value of Segment Number (0062,0004) shall be unique within the Segmentation instance in which it is created. See Section C.8.20.2.4.
Segment Label	(0062,0005)	1	User-defined label identifying this segment. This may be the same as Code Meaning (0008,0104) of Segmented Property Type Code Sequence (0062,000F).
Segment Description	(0062,0006)	3	User-defined description for this segment.
Segment Algorithm Type	(0062,0008)	1	Type of algorithm used to generate the segment. Enumerated Values: **AUTOMATIC** calculated segment **SEMIAUTOMATIC** calculated segment with user assistance **MANUAL** user-entered segment
Include Table 10-7b "Multiple Site General Anatomy Optional Macro Attributes"			*May not be necessary if the anatomy is implicit in the Segmented Property Type Code Sequence.* *More than one Item in Anatomic Region Sequence (0008,2218) may be used when a region of interest spans multiple anatomical locations and there is not a single pre-coordinated code describing the combination of locations.* *There is no requirement that the multiple locations be contiguous.*
Segmented Property Category Code Sequence	(0062,0003)	1	Sequence defining the general category of the property the segment represents. Only a single Item shall be included in this Sequence.
>Include Table 8.8-1 "Code Sequence Macro Attributes"			*BCID 7150 "Segmentation Property Categories".*
Segmented Property Type Code Sequence	(0062,000F)	1	Sequence defining the specific property the segment represents. Note "Property" is used in the sense of meaning "what the segmented voxels represent", whether it be a physical or biological object, be real or conceptual, having spatial, temporal or functional extent or not. I.e., it is what the segment "is" (as opposed to some feature, attribute, quality, or characteristic of it, like color or shape or size). Only a single Item shall be included in this Sequence.
>Include Table 8.8-1 "Code Sequence Macro Attributes"			*BCID 7151 "Segmentation Property Types".*
>Segmented Property Type Modifier Code Sequence	(0062,0011)	3	Sequence defining the modifier of the property type of this segment. One or more Items are permitted in this Sequence.

Attribute Name	Tag	Type	Attribute Description
>>Include Table 8.8-1 "Code Sequence Macro Attributes"			*DCID 244 "Laterality"* ***for paired anatomic parts, or DCID 212 "Generic Anatomic Location Modifiers" as appropriate.*** **Note** **For Retinal Segmentation Surfaces, laterality is not typically specified.**
Tracking ID	(0062,0020)	1C	A text label used for tracking a finding or feature, potentially across multiple reporting objects, over time. This label shall be unique within the domain in which it is used. Required if Tracking UID (0062,0021) is present. Note 1. May or may not have the same value as Segment Label (0062,0005). 2. Related SR instances may exist, for example, to record measurements related to this segment, but need not exist for this Attribute to be used. 3. This Attribute will have the same value as the value of the (112039, DCM, "Tracking Identifier") Content Item in SR instances that reference this Segment in this Segmentation Instance.
Tracking UID	(0062,0021)	1C	A unique identifier used for tracking a finding or feature, potentially across multiple reporting objects, over time. Required if Tracking ID (0062,0020) is present. Note 1. Related SR instances may exist, for example, to record measurements related to this segment, but need not exist for this Attribute to be used. 2. This Attribute will have the same value as the value of the (112040, DCM, "Tracking Unique Identifier") Content Item in SR instances that reference this Segment in this Segmentation Instance.
Definition Source Sequence	(0008,1156)	3	Instances containing the source of the Segment information. Only a single Item is permitted in this Sequence.
>Include Table 10-11 "SOP Instance Reference Macro Attributes".			
>Referenced ROI Number	(3006,0084)	1C	The value of ROI Number (3006,0022) in the referenced SOP Instance that identifies the ROI that is the origin of the Segment information. Required if Referenced SOP Class UID (0008,1150) is RT Structure Set Storage ("1.2.840.10008.5.1.4.1.1.481.3").
Include Table 10.9.3-1 "Content Creator Macro Attributes"			

255 *Add new section for Height Map Segmentation Image Module to Annex C*

C.8.20.5 Height Map Segmentation Image Module

Table C.8.20-5 defines the Attributes of the Height Map Segmentation Image Module.

Table C.8.20-5. Height Map Segmentation Image Module Attributes

Attribute Name	Tag	Type	Attribute Description
Image Type	(0008,0008)	1	Image identification characteristics. Value 1 shall be DERIVED. Value 2 shall be PRIMARY. No other values shall be present.
Include Table 10-12 "Content Identification Macro Attributes"			
Samples Per Pixel	(0028,0002)	1	Number of samples (planes) in this image. Enumerated Values: **1**
Photometric Interpretation	(0028,0004)	1	The intended interpretation of the pixel data. Enumerated Values: **MONOCHROME2**
Rows	(0028,0010)	1	Number of rows in the image. Value shall be identical to the number of frames referenced in the Derivation Image. See Section C.8.20.5.2.
Columns	(0028,0011)	1	Number of columns in the image. Value shall be identical to value of Columns (0028,0011) in the Derivation Image. See Section C.8.20.5.1
Segmentation Type	(0062,0001)	1	The type of encoding used to indicate the presence of the segmented property at a location in the derivation image. See Section C.8.20.5.1 Enumerated Value: **HEIGHTMAP**
Segment Sequence	(0062,0002)	1	Describes the segments that are contained within the data. One or more Items shall be included in this Sequence.
>Include Table C.8.20-4 "Segment Description Macro Attributes"			
>Segment Algorithm Name	(0062,0009)	1C	Name of algorithm used to generate the segment. Required if Segment Algorithm Type (0062,0008) is not MANUAL.
>Segmentation Algorithm Identification Sequence	(0062,0007)	1C	A description of how this segment was derived. Algorithm Name (0066,0036) within this Sequence may be identical to Segment Algorithm Name (0062,0009). Required if Segment Algorithm Type (0062,0008) is not MANUAL. Only a single Item is permitted in this Sequence.
>>Include Table 10-19 "Algorithm Identification Macro Attributes"			*BCID 7162 "Surface Processing Algorithm Families".*

Attribute Name	Tag	Type	Attribute Description
>Recommended Display Grayscale Value	(0062,000C)	3	A default single gray unsigned value in which it is recommended that this segment be rendered on a monochrome display. The units are specified in P-Values from a minimum of 0000H (black) up to a maximum of FFFFH (white).
>Recommended Display CIELab Value	(0062,000D)	3	A default triplet value in which it is recommended that this segment be rendered on a color display. The units are specified in PCS-Values, and the value is encoded as CIELab. See Section C.10.7.1.1.

C.8.20.5.1 HEIGHTMAP Segmentation and Columns

Segmentation Type (0062,0001) of HEIGHTMAP specifies a segmented surface within a referenced derivation image pixel/voxel matrix volume. Each row of a Height Map Segmentation frame corresponds to a single full frame of a derivation image (see Section A.91.5.1.1) and shall have the same value for Columns (0028,0011).

The Height Map Segmentation Float Pixel Data (7FE0,0008) value specifies the location of the segmented surface in the corresponding pixel column in the referenced derivation image (see Figure C.8.20.5-1). The location is specified in units of vertical pixels from the top center of the column in the derivation image, with the floating point value providing fractional pixel resolution (see Figure C.8.20.5-2).

Note The DICOM convention is to specify fractional pixel offsets from the top left hand corner of an image. Since the horizontal offset is specified by column correspondence between the derivation image and the Height Map Segmentation, the horizontal position is nominally the midline of the column.

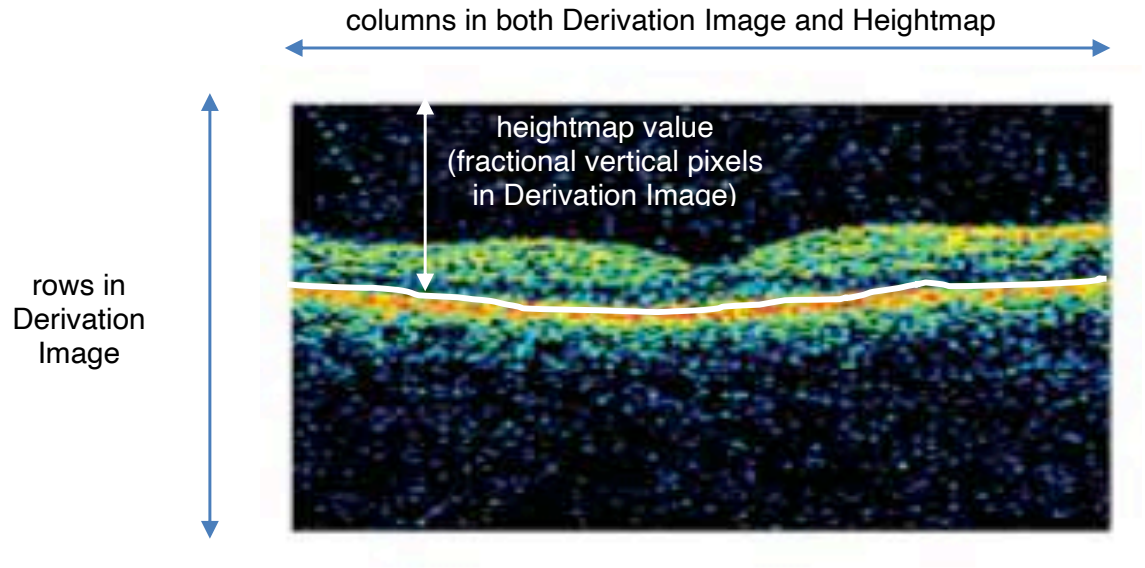

Figure C.8.20.5-1 - Height Map Segmentation Mapped onto Derivation Image Frame

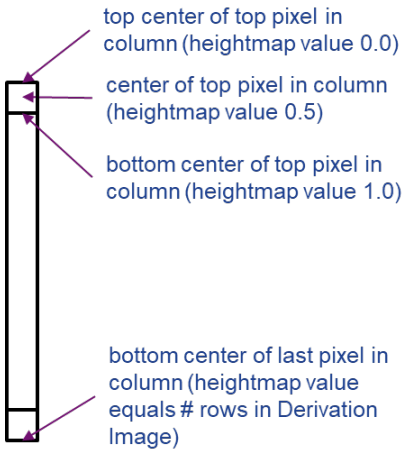

Figure C.8.20.5-2 - Height Map Fractional Pixel Resolution in Derivation Image Column

A segmented surface might not span the entire frame of a derivation image, and therefore there would be columns for which there is no valid height map value. The absence of a segmented surface in a derivation image pixel column is specified by a “padding value” in the height map, i.e., a height map value in the range specified by Float Pixel Padding Value (0028,0122) and Float Pixel Padding Range Limit (0028,0124) in the Floating Point Image Pixel Module (see Section C.7.6.24). The padding value range shall not overlap the range of zero to the number of rows of the derivation image.

C.8.20.5.2 Rows

One height map frame with multiple rows may specify the height map across all the referenced frames only if the Height Map Segmentation is specified for multiple, equally spaced parallel frames of the referenced derivation image. The multiple frames of the derivation image may be encoded in a single multi-frame SOP Instance, or in a Series of single frame or multi-frame SOP Instances, as long as the frames are parallel, equally sized, and equally spaced.

The segmentation might not extend across all of the frames of the SOP Instances referenced in the Derivation Image Functional Group. All the frames that are segmented shall be enumerated.

Notes

1. A height map with multiple rows might be used for segmentation of a cube-scan OPT image. Referenced OPT images with equal slice spacing might have the Ophthalmic Volumetric Properties Flag (0022,1622) value YES.
2. The height map may be specified for a subset of frames of the derivation image. The frames in the subset are not necessarily adjacent, e.g., if only even numbered frames are segmented. As long as the referenced frames are equally spaced, a single height map frame with multiple rows may specify the height map across all the referenced frames

The value of Rows (0028,0010) of the Height Map Segmentation shall equal the number of frames referenced in the derivation image. The orientation of a Height Map Segmentation frame with more than one row is thus orthogonal to the orientation of the derivation image frames. See example in Figure C.8.20.5-3.

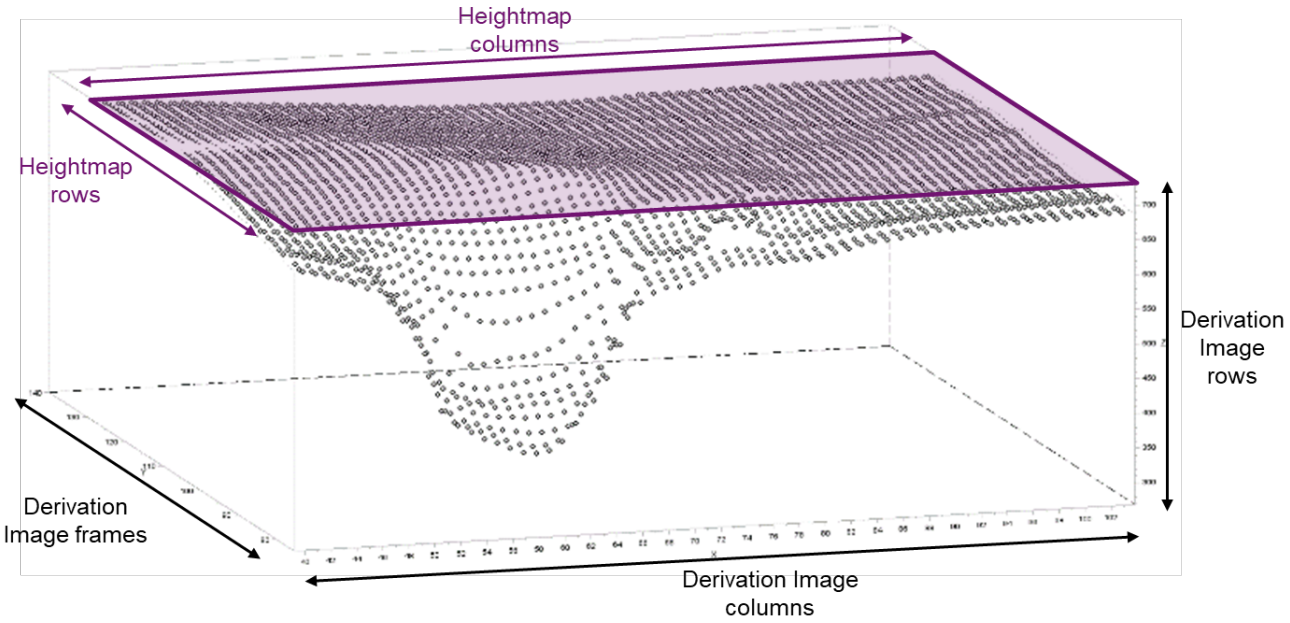

Figure C.8.20.5-3 – 2D Height Map Pixel Values Rendered into 3D Volume of Derivation Image

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Revise Ophthalmic OCT En Face Image Module to allow any Segmentation type rather than requiring Surface Segmentation, and add reference to a localizer image

C.8.17.14 Ophthalmic Optical Coherence Tomography En Face Image Module

310 Table C.8.17.14-1 specifies the Attributes that describe the Ophthalmic Optical Coherence Tomography En Face Image Module.

Table C.8.17.14-1. Ophthalmic Optical Coherence Tomography En Face Image Module Attributes

Attribute Name	Tag	Type	Attribute Description
Image Type	(0008,0008)	1	Image identification characteristics. See Section C.8.17.14.1.5 for specialization.
…			
Pixel Representation	(0028,0103)	1	Data representation of pixel samples. Enumerated Values: 0**000H** **unsigned integer**
Pixel Spacing	(0028,0030)	1	Nominal physical distance at the focal plane (in the retina) between the center of each pixel, specified by a numeric pair - adjacent row spacing (delimiter) adjacent column spacing in mm. See Section 10.7.1.3 for further explanation of the value order. *Note* *Since a patient's retina is curved and the image representation is planar, there can be an error in using Pixel Spacing (0028,0030) for measurements in the periphery of the image. En face imaging does not support wide field measurements.*
Image Orientation (Patient)	**(0020,0037)**	**1**	**The direction cosines of the first row and the first column with respect to the patient. See Section C.7.6.2.1.1 for further explanation.** ***Note*** ***Since the coordinate system associated with the Frame of Reference is deformed and the selected en face data volume might be non-planar, the orientation will be a nominal real world orientation.***
Ophthalmic Frame Location Sequence	**(0022,0031)**	**1**	**Specifies the location of this image in terms of location on a referenced localizer image.** **Only a single Item shall be included in this Sequence.**
>Include Table 10-3 "Image SOP Instance Reference Macro Attributes"			
>Reference Coordinates	**(0022,0032)**	**1**	**Image coordinates for the points on the referenced image that correspond to the Top Left Hand Corner (TLHC) and the Bottom Right Hand Corner (BRHC) of the En Face Image.** **Exactly two pairs of values where the first value of each pair is the row (vertical) offset and the second value of each pair is the column (horizontal) offset.** **Specified with sub-pixel resolution such that the origin at the Top Left Hand Corner (TLHC) of the TLHC pixel is 0.0\0.0, the Bottom Right Hand Corner (BRHC) of the TLHC pixel is 1.0\1.0,**

			and the BRHC of the BRHC pixel is Rows\Columns (see Figure C.10.5-1, except that row and column order is reversed). The values must be within the range 0\0 to Rows\Columns of the referenced image. **See Section C.8.17.10.1.1. Alignment of an En Face Image is equivalent to that of a transverse OPT Image.**
Content Time	(0008,0033)	1	The time the image pixel data creation started.
…			
Derivation Algorithm Sequence	(0022,1612)	1	Software algorithm that performed the derivation. Only a single Item shall be included in this Sequence.
>Include Table 10-19 "Algorithm Identification Macro Attributes"			***~~DCID 4270 "OCT-A Processing Algorithm Family"~~ DCID 4274 "En Face Processing Algorithm Family"*** *shall be used for Algorithm Family Code Sequence (0066,002F)* **Note Additional processing, such as artifact removal, that are used in the derivation but not strictly part of the algorithm, can be described in Algorithm Parameters (0066,0032).**
…			
Ophthalmic FOV	(0022,1517)	3	The horizontal field of view used to capture the ophthalmic image, in degrees. The field of view is the maximum image size displayed on the image plane, expressed as the angle subtended at the exit pupil of the eye by the maximum dimension 2r (where r equals the radius).
Ophthalmic En Face Volume Descriptor Sequence	**(0022,1627)**	**1**	**Description of the volume or boundary surfaces used to select the en face image data from the source image(s).** **One or two Items shall be included in this Sequence.** **See Section C.8.17.14.1.2 for further explanation.**
>Ophthalmic En Face Volume Descriptor Scope	**(0022,1629)**	**1**	**Part of the en face volume described by this Item.** **Enumerated Values** **ANTERIOR Anterior surface of volume** **POSTERIOR Posterior surface of volume** **ENTIRE Entire volume** **If value is ENTIRE, this Item shall be the only Item in the Ophthalmic En Face Volume Descriptor Sequence (0022,1627). Otherwise, two Items shall be included in the Ophthalmic En Face Volume Descriptor Sequence (0022,1627), one with value ANTERIOR and the other with value POSTERIOR.** **Note: Anterior and posterior surfaces are defined in terms of the orientation of the en face volume within the patient coordinate system in the source image(s).**

>Referenced ~~Surface Mesh Identification~~ Segmentation Sequence	(~~0022,1620~~ 0008,114C)	1C	Reference to the ~~surface mesh(s)~~ segmentations used in the ~~creation of this SOP Instance~~ selection of the en face data. One or more Items shall be included in this Sequence. Required if segmentation is used to select the en face data volume or surface. See Section C.8.17.14.1.2 for further explanation.
~~>Referenced SOP Instance UID~~	~~(0008,1155)~~	~~1~~	~~Referenced SOP Instance that contains the surface segmentation used in the creation of this SOP Instance.~~
~~>Referenced Surface Number~~	~~(0066,002C)~~	~~1~~	~~Reference to a Surface Number (0066,0003) present in Surface Sequence (0066,0002).~~
>>Include Table 10-3 "Image SOP Instance Reference Macro"			Reference to a segmentation SOP Instance and one or more segments thereof in Referenced Segment Number (0062,000B). Referenced Segment Number (0062,000B) shall be present, even if the referenced segmentation SOP Instance contains only a single segment. Note The SOP Class of the segmentation is not constrained.
>>Segmented Property Type Code Sequence	(0062,000F)	1	Sequence defining the specific property the ~~surface~~ segmentation represents. The Items in this Sequence shall be copied from the Segmented Property Type Code Sequence (0062,000F) of the referenced segmentation. ~~Only a single Item is permitted in this Sequence.~~ The number of Items in this Sequence shall equal the number of values in Referenced Segment Number (0062,000B). ~~Note~~ ~~"Property" is used in the sense of meaning "what the surface represents", whether it be a physical or biological object, be real or conceptual, having spatial, temporal or functional extent or not. I.e., it is what the segment "is" (as opposed to some feature, Attribute, quality, or characteristic of it, like color or shape or size).~~
>>*Include Table 8.8-1 "Code Sequence Macro Attributes"*			~~*BCID 4273 "Retinal Segmentation Surfaces".*~~
>>>Segmented Property Type Modifier Code Sequence	**(0062,0011)**	**3**	**Sequence defining the modifier of the property type of this segment.** **One or more Items are permitted in this Sequence.**
>>>>Include Table 8.8-1 "Code Sequence Macro Attributes"			
~~**>Surface Mesh Z-Pixel Offset**~~	~~**(0022,1658)**~~	~~**1**~~	~~Offset in number of pixels along the z axis by which the mesh data has been shifted when generating this SOP Instance~~ ~~The mesh data is the Attribute Point Coordinates Data (0066,0016) of the surface mesh referenced by Attribute Referenced SOP Instance UID (0008,1155).~~ ~~Note~~ ~~If no offset is used the value is set to 0.~~

>Surface Offset	**(0066,0005)**	**1**	**Offset in pixels from the referenced segmentation surface, in the direction from the top towards the bottom of the source image frames. If no referenced segmentation surface is specified in this Item of Ophthalmic En Face Volume Descriptor Sequence (0022,1627), the offset is from the top of the source image frames.** **If no offset is used the value is set to 0.** **See Section C.8.17.14.1.2.**
>Surface Processing Description	**(0066,000B)**	**3**	**A description of processing performed to construct the surface, such as interpolation between referenced segmented surfaces.**
Ophthalmic Axial Length	(0022,1019)	3	The axial length measurement, in mm.

C.8.17.14.1 Ophthalmic Optical Coherence Tomography En Face Image Module Attribute Descriptions

In this Section, the term "surface segmentation" (uncapitalized) is a generic reference to any type of segmentation that describes a surface. It includes both the Surface Segmentation IOD or SOP Class (capitalized) and the Height Map Segmentation IOD or SOP Class.

C.8.17.14.1.1 Source Image Sequence

An OCT en face image is derived from images obtained using OCT technology. The Source Image Sequence (0008,2112) shall convey the SOP Instances used to derive this en face SOP Instance.

If Attribute Purpose of Reference Code Sequence (0040,A170) is set to (128250, DCM, "Structural image for image processing"), the Source Image Sequence will reference an Ophthalmic Tomography SOP Instance.

If Attribute Purpose of Reference Code Sequence (0040,A170) is set to (128251, DCM, "Flow image for image processing"), the Source Image Sequence will reference an Ophthalmic Optical Coherence Tomography B-scan Volume Analysis SOP Instance.

A typical example of the image processing stages performed to generate en face images is shown in Figure C.8.17.14-1.

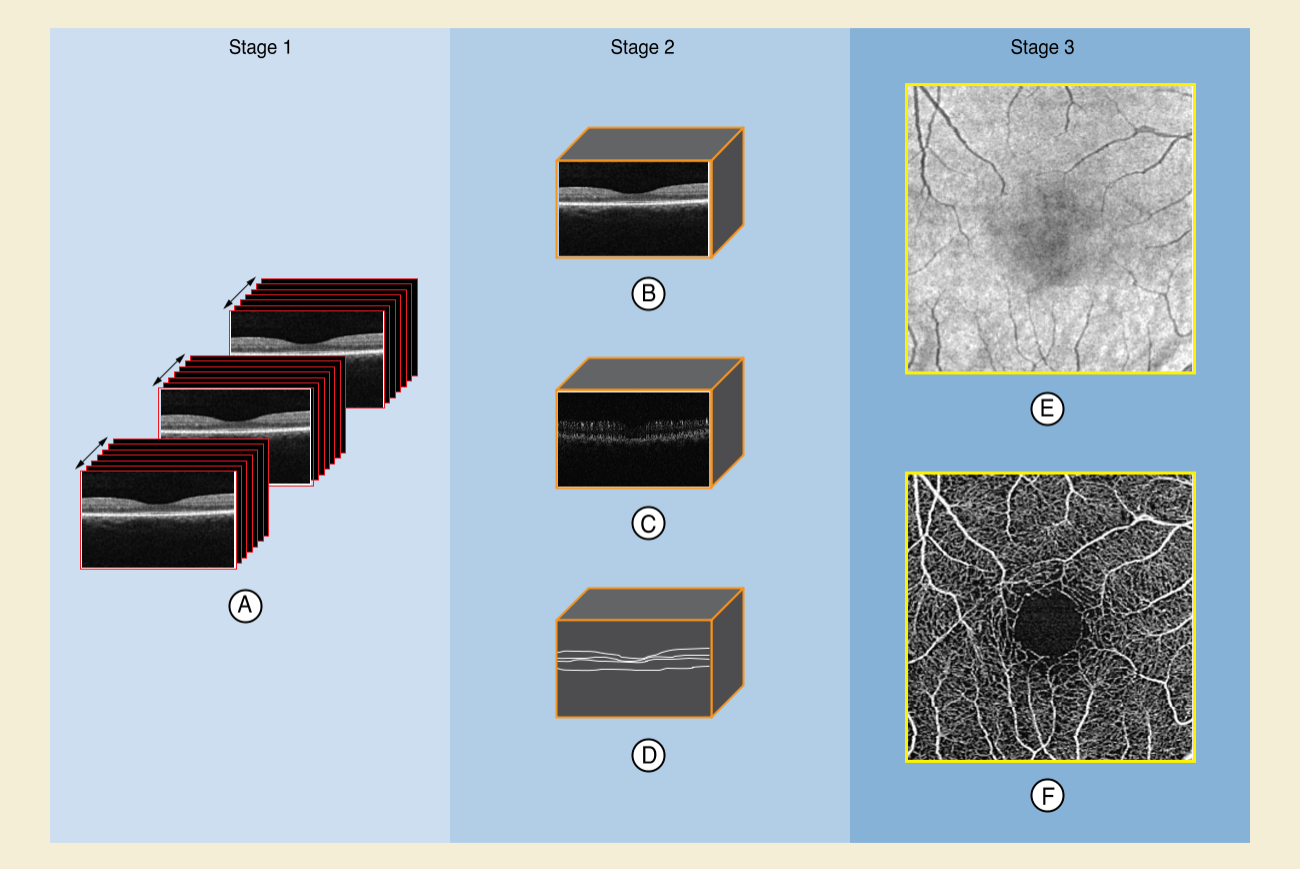


Figure C.8.17.14-1. Example of the Image Process Performed to Generate En Face Images

Figure Legend:

A. OCT proprietary B-scan data (possibly a DICOM Raw Data Instance)

B. Volumetric structural ophthalmic tomography image (Ophthalmic Tomography Image Instance)

C. OCT angiographic flow volume information (Ophthalmic Optical Coherence Tomography B-scan Volume Analysis Instance)

D. OCT surface ~~mesh~~**segmentation** (**e.g., Height Map Segmentation or** Surface Segmentation Instance)

E. Structural en face image (Ophthalmic Optical Coherence Tomography En Face Image Instance)

F. En Face angiographic flow image (Ophthalmic Optical Coherence Tomography En Face Image Instance)

Stage 1: OCT technology is used to acquire a volumetric dataset from a retinal region of interest. This volumetric dataset (A) consists of multiple B-scans in a raster pattern, and multiple frames are acquired at each B-scan location. The B-scans are acquired in the manufacturer's proprietary format for analysis and storage. If this information is stored in DICOM, it can use the Raw Data Storage SOP Class.

Stage 2: The OCT proprietary B-scan data (A) (or DICOM Raw Data SOP Instance) is then analyzed to derive the volumetric structural ophthalmic tomography image (B). From (B) one or more OCT surface ~~meshes~~**segmentations** (D) are generated to delineate the anatomical boundaries. The difference in signal between the frames of each individual B-scan is analyzed to produce the OCT angiographic flow volume information (C).

Stage 3: Clinicians typically make their assessment based upon two types of OCT en face images. The structural OCT en face image (E) is derived by using pixel information in (B) and two surface ~~meshes~~**segmentations** (D). The OCT angiographic

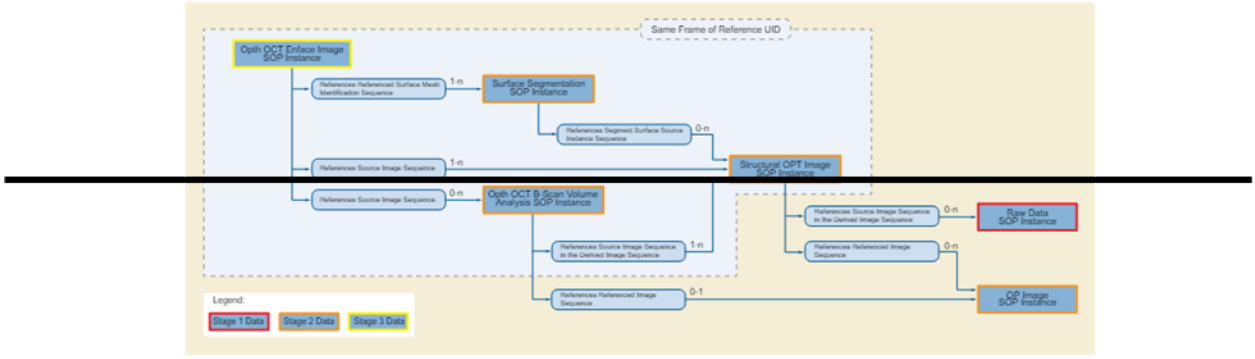
flow en face image (F) may be derived using the OCT angiographic flow volume information (C) and the OCT surface ~~mesh~~**segmentations** (D).

En face images are typically derived by the acquisition modality that generated the Ophthalmic Tomography Image, ~~S~~**s**urface ~~S~~**s**egmentation, and Ophthalmic Optical Coherence Tomography B-scan Volume Analysis SOP Instances**,** or by image workstations that received the respective Ophthalmic Image, ~~S~~**s**urface ~~S~~**s**egmentation, and Ophthalmic Optical Tomography B-scan Volume Analysis SOP Instances via DICOM Storage.

Note

Image workstations receiving ophthalmic tomography images may choose to evaluate the structural ophthalmic tomography image and generate a different set of segmented surfaces than defined by an acquisition device. The surface segmentation information can be stored in a separate ~~Surface~~ ~~S~~**s**egmentation SOP Instance.

The Ophthalmic Tomography Image, ~~S~~**s**urface ~~S~~**s**egmentation, Ophthalmic Optical Coherence Tomography B-scan Volume Analysis and the Ophthalmic Optical Coherence Tomography En Face Image SOP Instances all reside in different DICOM Series. They share the same spatial Frame of Reference which is identified in Attribute Frame of Reference UID (0020,0052) (i.e., the value of Frame of Reference UID (0020,0052) is the same in each SOP Instance). Figure C.8.17.14-2 illustrates the relationships between the OCT angiography based SOP Instances.



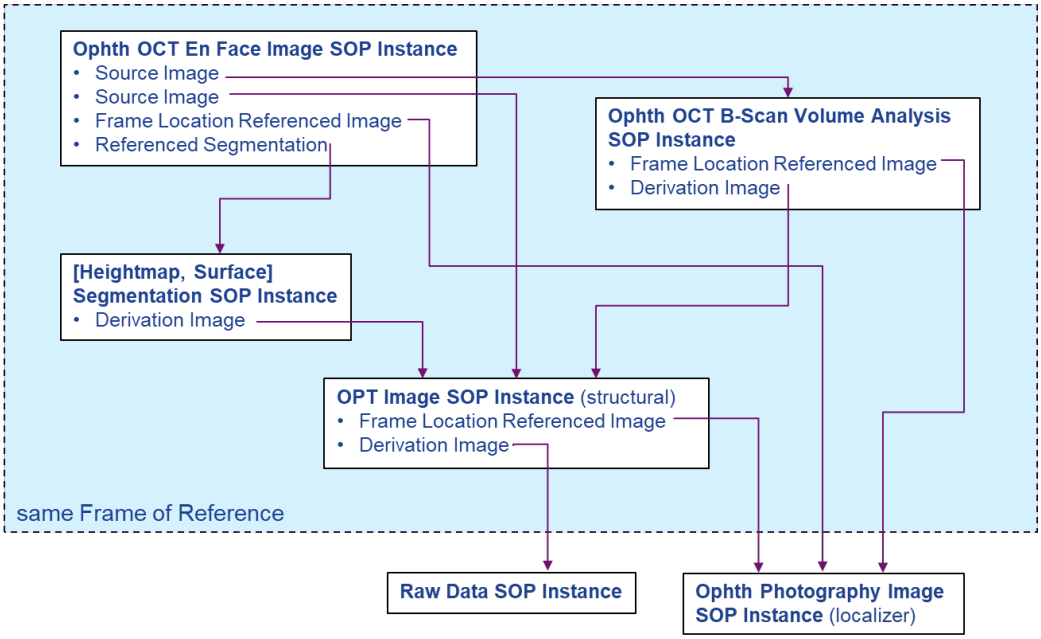


Figure C.8.17.14-2. Relationships Between OCT-A Based SOP Instances

C.8.17.14.1.2 ~~Referenced Surface Mesh Identification~~ Ophthalmic En Face Volume Descriptor Sequence

~~Referenced Surface Mesh Identification Sequence (0022,1620) identifies one or more segmentation surfaces used to generate the derived en face image. The segmented surfaces are described in the SOP Instance identified by Referenced SOP Instance UID (0008,1155) (e.g., Surface Segmentation Storage SOP Instance).~~

The Items of the Ophthalmic En Face Volume Descriptor Sequence (0022,1627) identify the parameters used to select the data volume (slab) from the source image(s) for the derived en face image. The en face image data may be selected by a volumetric segmentation specified in a single Item of the Ophthalmic En Face Volume Descriptor Sequence (0022,1627), or by specifying an anterior and a posterior surface respectively in two Items.

Anterior and posterior surfaces may each be specified by

- a referenced surface segmentation,
- a combination (e.g., interpolation) of two referenced surface segments,
- a fixed offset from a referenced surface segmentation, or
- a fixed offset from the top of the source image frames.

If a referenced segmentation does not extend to the full pixel matrix of the en face image, the en face pixel values outside the extent of the segment are implementation specific. If the surfaces intersect, or reverse (anterior surface behind the posterior), the en face pixel values at the points of intersection or reversal are implementation specific.

Note Such pixels may be represented with values in the Pixel Padding range.

Surface Offset (0066,0005) specifies an offset from the referenced segmentation surface to the surface of the en face image slab. If no segmentation is referenced in the same Item of the Ophthalmic En Face Volume Descriptor Sequence (0022,1627), the offset is from the top of the source image frames (i.e., the boundary surface is flat relative to the source image volume). The offset is a fractional number of pixels relative to the top of the frames of the source image, i.e., a positive number indicates offset toward the bottom of the frame.

Notes 1. The two en face data boundary surfaces may be specified relative to the same referenced segmentation surface, potentially with different offsets. The reference is duplicated in the two Items of the Ophthalmic En Face Volume Descriptor Sequence (0022,1627).

2. An ENTIRE en face data volume may be specified by two referenced surface segments in a single Item of the Ophthalmic En Face Volume Descriptor Sequence (0022,1627). The two referenced segments may be specified in two Items of the Referenced Segmentation Sequence (0008,114C), or by a single Item that identifies two surfaces in Referenced Segment Number (0062,000B).

3. An en face data boundary surface may be specified by a combination (e.g., interpolation) of multiple referenced segments. The multiple referenced segments may be specified in multiple Items of the Referenced Segmentation Sequence (0008,114C), or by a single Item that identifies multiple surfaces in Referenced Segment Number (0062,000B). The nature of the combination may be described in Surface Processing Description (0066,000B).

4. An application that wishes to specify an offset that has been determined in real world units, e.g., 0.015 mm above the segmented surface, must calculate the offset in pixels by using the pixel measures (row spacing) of the segmentation derivation image to convert from real world distances to fractional number of pixels, and use that value in the Surface Offset (0066,0005) Attribute.

5. This Module allows the creating application to record its processing for purposes of provenance and traceability. It does not necessarily provide sufficient information for a receiving application to reproduce an identical en face image.

DICOM PS3.4: Service Class Specifications

Add Height Map Segmentation to Annex B Storage Service Class

.

Table B.5-1. Standard SOP Classes

SOP Class Name	SOP Class UID	IOD Specification (defined in PS3.3)	Specialization
…			
Height Map Segmentation Storage	**1.2.840.10008.5.1.4.1.1.66.8**	**Height Map Segmentation IOD**	

DICOM PS 3.6: Data Dictionary

Add new data elements to Section 6 Registry of DICOM Data Elements

Table 6-1. Registry of DICOM Data Elements

Tag	Name	Keyword	VR	VM	
…					
(0022,1627)	Ophthalmic En Face Volume Descriptor Sequence	OphthalmicEnFaceVolumeDescriptorSequence	SQ	1	
(0022,1629)	Ophthalmic En Face Volume Descriptor Scope	OphthalmicEnFaceVolumeDescriptorScope	CS	1	
(0008,114C)	Referenced Segmentation Sequence	ReferencedSegmentationSequence	SQ	1	
(0066,0005)	Surface Offset	SurfaceOffset	FL	1	

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Add new UIDs to Annex A Registry of DICOM Unique Identifiers (UIDs)

Table A-1. UID Values

UID Value	UID Name	UID Keyword	UID Type	Part
1.2.840.10008.5.1.4.1.1.66.8	Height Map Segmentation Storage	HeightMapSegmentationStorage	SOP Class	PS3.4

430 **Table A-3. Context Group UID Values**

Context UID	Context Identifier	Context Group Name	Comment
1.2.840.10008.6.1.1496	CID 4274	En Face Processing Algorithm Family	
1.2.840.10008.6.1.1497	CID 4275	Anterior Eye Segmentation Surface	

DICOM PS 3.16: Content Mapping Resource

Add new concepts for En Face Image Type

CID 4271 En Face Image Type

Keyword: EnFaceImageType

FHIR Keyword: dicom-cid-4271-EnFaceImageType

Type: Extensible

Version: ~~20170405~~ **20240915**

UID: 1.2.840.10008.6.1.1151

Table CID 4271. En Face Image Type

Coding Scheme Designator	Code Value	Code Meaning
DCM	128257	Retina depth encoded vasculature flow
DCM	128258	Retina depth encoded structural reflectance map
DCM	128259	Retina vasculature flow
DCM	128260	Retina structural reflectance map
DCM	128261	Vitreous vasculature flow
DCM	128262	Vitreous structural reflectance map
DCM	128263	Radial peripapillary vasculature flow
DCM	128264	Radial peripapillary structural reflectance map
DCM	128265	Superficial retina vasculature flow
DCM	128266	Superficial retina structural reflectance map
DCM	128267	Middle inner retina vasculature flow
DCM	128268	Middle inner structural reflectance map
DCM	128269	Deep retina vasculature flow
DCM	128270	Deep retina structural reflectance map
DCM	128271	Outer retina vasculature flow
DCM	128272	Outer retina structural reflectance map
DCM	128273	Choriocapillaris vasculature flow
DCM	128274	Choriocapillaris structural reflectance map
DCM	128275	Choroid vasculature flow
DCM	128276	Choroid structural reflectance map
DCM	128277	Whole eye vasculature flow
DCM	128278	Whole eye structural reflectance map
DCM	**128306**	**Avascular complex flow**
DCM	**128307**	**Avascular complex map**
DCM	**128308**	**Superficial vascular plexus flow**
DCM	**128309**	**Superficial vascular plexus map**
DCM	**128310**	**Deep capillary plexus flow**
DCM	**128311**	**Deep capillary plexus map**
DCM	**128312**	**RNFL vascular plexus flow**
DCM	**128313**	**RNFL vascular plexus map**
DCM	**128314**	**User selected volume flow**
DCM	**128315**	**User selected volume structure map**
DCM	**128316**	**ORCC vasculature flow**
DCM	**128317**	**ORCC structural reflectance map**

Update CID 4273 with revised nomenclature and additional concepts

CID 4273 Retinal Segmentation Surface

Keyword: RetinalSegmentationSurface

FHIR Keyword: dicom-cid-4273-RetinalSegmentationSurface

Type: Extensible

Version: ~~**20170405**~~ **20240915**

UID: 1.2.840.10008.6.1.1153

Table CID 4273. Retinal Segmentation Surface

Coding Scheme Designator	Code Value	Code Meaning	SNOMED-RT ID	UMLS Concept Unique ID
SCT	280677004	ILM – Internal limiting membrane	T-AA62D	C0459664
DCM	128289	Outer surface of RNFL		
DCM	128290	Outer surface of GCL		
DCM	128291	Outer surface of IPL		
DCM	128292	Outer surface of INL		
DCM	128293	Outer surface of OPL		
DCM	128294	Outer surface of HFL		
SCT	76710003	ELM – External limiting membrane	T-AA650	C0229209
~~**DCM**~~	~~**128295**~~	~~**Surface between Inner and Outer Segments of the photoreceptors**~~		
~~**DCM**~~	~~**128296**~~	~~**Surface of the interdigitating zone between retina and RPE**~~		
DCM	128297	~~**Anterior**~~ **Inner** surface of the RPE		
DCM	128298	Surface of the center of the RPE		
DCM	128299	~~**Posterior**~~ **Outer** surface of the RPE		
DCM	128300	Outer surface of ~~**the BM**~~**Bruch's Membrane**		
DCM	128301	Surface of the choroid-sclera interface		
DCM	128302	Outer surface of the CC		
SCT	**30322002**	**Lamina cribrosa of sclera**	**T-AA120**	**C0229114**
DCM	**128320**	**Inner surface of the ellipsoid zone**		
DCM	**128321**	**Midline of the ellipsoid zone**		
DCM	**128322**	**Outer surface of the ellipsoid zone**		
DCM	**128323**	**Inner surface of the interdigitation zone**		
DCM	**128324**	**Outer surface of the interdigitation zone**		

Notes:

1. **(128295, DCM, "Surface between Inner and Outer Segments of the photoreceptors"), previously included in this Context Group, has been deprecated in favor of the concepts (128320, DCM, "Inner surface of the ellipsoid zone"), (128321, DCM, "Midline of the ellipsoid zone"), and (128322, DCM, "Outer surface of the ellipsoid zone"),**

2. **(128296, DCM, "Surface of the interdigitation zone between retina and RPE"), previously included in this Context Group, has been deprecated in favor of the concepts (128323, DCM, "Inner surface of the interdigitation zone") and (128324, DCM, "Outer surface of the interdigitation zone").**

Add new Context Group for En Face Algorithms

CID 4274 En Face Processing Algorithm Family

Keyword: EnFaceProcessingAlgorithmFamily

FHIR Keyword: dicom-cid-4274-EnFaceProcessingAlgorithmFamily

Type: Extensible

Version: 20240915

UID: 1.2.840.10008.6.1.1496

Table CID 4274. En Face Processing Algorithm Family

Coding Scheme Designator	Code Value	Code Meaning
Include CID 4270 OCT-A Processing Algorithm Family		
DCM	113078	Maximum intensity projection
DCM	113079	Minimum intensity projection
DCM	130924	Mean intensity projection
DCM	130925	Median intensity projection
DCM	130926	Summation projection

Add new Context Group for anterior eye segmented surfaces

CID 4275 Anterior Eye Segmentation Surface

Keyword: AnteriorEyeSegmentationSurface

FHIR Keyword: dicom-cid-4275-AnteriorEyeSegmentationSurface

Type: Extensible

Version: 20240915

UID: 1.2.840.10008.6.1.1497

Table CID 4275. Anterior Eye Segmentation Surface

Coding Scheme Designator	Code Value	Code Meaning
SCT	15775008	Corneal epithelium
SCT	65431007	Corneal endothelium
SCT	22040008	Anterior surface of iris
SCT	53695005	Posterior surface of iris
SCT	85013008	Anterior surface of lens
SCT	47813007	Posterior surface of lens
SCT	55143001	Bowman's layer
SCT	50546002	Stroma of cornea
SCT	42983006	Descemet's membrane
SCT	74235007	Inner surface of sclera
SCT	34683007	External surface of sclera

Update CID 7192 listing segmentation properties with anterior eye segments

CID 7192 Anatomical Structure Segmentation Property Type

…

Version: ~~20220402~~ 20240915

UID: 1.2.840.10008.6.1.1191

Table CID 7192. Anatomical Structure Segmentation Property Type

Coding Scheme Designator	Code Value	Code Meaning	
…			
Include CID 4275 Anterior Eye Segmentation Surface			

Update definitions in Annex D Table D-1

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Code Value	Code Meaning	Definition	Notes
128296	Surface of the ~~**interdigitating**~~ **interdigitation** zone between retina and RPE	Retinal surface located approximately at the retina-RPE ~~**interdigitating**~~ **interdigitation** zone when present.	
128297	~~**Anterior**~~ **Inner** surface of the RPE	~~**Retinal surface located approximately at the anterior**~~ **Inner** surface of the Retinal Pigment Epithelium (RPE).	
128298	Surface of the center of the RPE	~~**Retinal**~~ **Segmentation** surface located approximately at the center of the Retinal Pigment Epithelium (RPE).	
128299	~~**Posterior**~~ **Outer** surface of the RPE	~~**Retinal surface located approximately at the posterior**~~ **Outer** surface of the Retinal Pigment Epithelium (RPE).	
128300	Outer surface of ~~**the BM**~~ **Bruch's Membrane**	Retinal surface located approximately at the outer boundary of the Bruch's Membrane (BM).	

Add new definitions to Annex D Table D-1

Code Value	Code Meaning	Definition	Notes
130924	Mean intensity projection	Values are derived by mean intensity projection of acquired data.	
130925	Median intensity projection	Values are derived by median intensity projection of acquired data	
130926	Summation projection	Values are derived by summation of values in the projection of acquired data	
128306	Avascular complex flow	Image that illustrates the vascular flow within the posterior layers of the retina, approximately from the posterior border of the outer plexiform layer (OPL) to the level of Bruch's Membrane (BM). For normal eyes, this image would not show detectable vascular flow.	
128307	Avascular complex map	Image that illustrates the structural reflectance within the posterior layers of the retina, approximately from the outer plexiform layer (OPL) to the level of Bruch's Membrane (BM).	

128308	Superficial vascular plexus flow	Image that illustrates the vascular flow within the anterior layers of retina, approximately from the posterior border of the retinal nerve fiber layer (RNFL) to the inner plexiform layer (IPL).	
128309	Superficial vascular plexus map	Image that illustrates the structural reflectance within the anterior layers of retina, approximately from the posterior border of the retinal nerve fiber layer (RNFL) to inner plexiform layer (IPL).	
128310	Deep capillary plexus flow	Image that illustrates the vascular flow within the plexiform layers of the retina, approximately from within the inner Nuclear layer (INL) to posterior border of the outer plexiform layer (OPL)	
128311	Deep capillary plexus map	Image that illustrates the structural reflectance within the plexiform layers of the retina, approximately from within the Inner Nuclear Layer (INL) to posterior border of the outer plexiform layer (OPL).	
128312	RNFL vascular plexus flow	Image that illustrates the vascular flow within the retinal nerve fiber layer (RNFL), approximately from inner limiting membrane (ILM) to the outer boundary of the RNFL.	
128313	RNFL vascular plexus map	Image that illustrates the structural reflectance within the retinal nerve fiber layer (RNFL), approximately from inner limiting membrane (ILM) to the outer boundary of the RNFL.	
128314	User selected volume flow	Image that illustrates the vascular flow within a volume selected by the user	
128315	User selected volume structure map	Image that illustrates the structural reflectance within a volume selected by the user	
128316	ORCC vasculature flow	Image that illustrates the vasculature flow within the posterior layers of the retina (including the outer retina), approximately from the posterior boundary of the outer plexiform layer (OPL) to the inner choriocapillaris (CC).	
128317	ORCC structural reflectance map	Image that illustrates the structural reflectance within the posterior layers of the retina (including the outer retina), approximately from posterior boundary of the outer plexiform layer (OPL) to the inner choriocapillaris (CC).	

128320	Inner surface of the ellipsoid zone	Inner surface of the retinal ellipsoid zone, also known as the photoreceptor inner segment/outer segment (IS/OS) junction	
128321	Midline of the ellipsoid zone	Segmentation surface located approximately midway between the inner and outer surfaces of the retinal ellipsoid zone	
128322	Outer surface of the ellipsoid zone	Outer surface of the retinal ellipsoid zone, also known as the photoreceptor inner segment/outer segment (IS/OS) junction	
128323	Inner surface of the interdigitation zone	Inner surface of the retinal interdigitation zone	
128324	Outer surface of the interdigitation zone	Outer surface of the retinal interdigitation zone	

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DICOM PS 3.17: Explanatory Information

Add explanatory Annex

Annex CCCCC Height Map Segmentation (Informative)

CCCCC.1 INTRODUCTION

In general computer graphics usage, a height map describes the distance ("height") of a surface perpendicular to a baseline plane within a volume, where a surface has at most one height position for each point on the baseline plane. The height map data is thus a 2D plane with a value at each coordinate position of the baseline plane. In the degenerate case of a volume consisting of a single vertical plane, the height map is a 1D series of data values.

DICOM Height Map Segmentation represents the height map of a surface within a volume as a 2D "image", with the pixel values representing the offset location of the surface. The volume is defined by the voxel matrix extent of a referenced multi-frame image, where the referenced image frames are perpendicular to the baseline plane of the Height Map Segmentation image frame. In the degenerate case of a referenced image being a single frame, the height map data for that frame can be represented by a single row of values.

Since DICOM height map data represents distance from the top of the referenced image pixel matrix, the height map might more accurately be described as a "depth map". However, that term has a different meaning in computer graphics processing, so DICOM uses the conventional term "height map".

CCCCC.2 TECHNICAL APPROACH

The Height Map Segmentation IOD uses an approach similar to the Segmentation IOD for planar segmentation without a Frame of Reference, which specifies segmentation in the imaging plane of a referenced image (the "derivation image") using that image's pixel spacing. The Height Map Segmentation specifies a single row of "pixels" (height data) aligned to each referenced image plane and pixel matrix. The segmented surface position is represented by the number of (fractional) rows from the top of the pixel matrix of the referenced image frame (in accordance with the DICOM convention of locating a position in an image by rows and columns offset from the top left corner). Since each referenced image frame has a single row of Height Map Segmentation data, a referenced multi-frame volume therefore has a set of Height Map Segmentation rows. If the referenced muti-frame image frames are regularly spaced, the Height Map Segmentation rows may be represented as a 2D plane orthogonal to the referenced image planes. See the description in PS3.3 Section C.8.20.5 and especially the following figures therein:

- Figure C.8.20.5-1 - Height Map Segmentation Mapped onto Derivation Image Frame
- Figure C.8.20.5-2 - Height Map Fractional Pixel Resolution in Derivation Image Column
- Figure C.8.20.5-3 - 2D Height Map Pixel Values Rendered into 3D Volume of Derivation Image

As with the Segmentation IOD, the Height Map Segmentation IOD allows a SOP Instance to describe multiple segments, i.e., layer surfaces. Each segment may be associated with one or more frames in the Height Map Segmentation SOP Instance.

Since a segmented surface might not extend across the entire referenced derivation image volume, typical DICOM pixel padding mechanisms are used. A Height Map Segmentation pixel value in the pixel padding range indicates the absence of the surface at the corresponding derivation image location.

Note that Height Map Segmentation does not use the second method defined in the Segmentation IOD for volumetric segmentation within a Frame of Reference, which allows segmentation in the real-world space defined by a Frame of Reference, with segmentation frame position, orientation, and matrix pixel spacing independent of the referenced image characteristics. Such an approach requires support for 3D volumetric reorientation and reconstruction, and is unnecessary for the primary height map use case.

CCCCC.3 COMPARISON TO SURFACE SEGMENTATION IOD

DICOM defines another method of specifying surfaces, the Surface Segmentation IOD and SOP Class. Surface Segmentation and Height Map Segmentation are designed for different use cases. Surface Segmentation provides a capability for representing a broad variety of surfaces within a volume. Height Map Segmentation supports a more limited capability with a simpler data structure and a significantly smaller data set. The more limited capabilities of Height Map Segmentation allow a simpler implementation, especially for receiving applications.

Surface Segmentation allows arbitrarily folded surfaces, while Height Map Segmentation allows one height position for each point on the baseline plane. Surface Segmentation specifies surfaces within a volumetric Frame of Reference, while Height Map Segmentation is aligned to the voxel matrix of a reference image. Surface Segmentation requires three 32-bit values for the (X,Y,Z) coordinates for each surface point, while Height Map Segmentation requires only one 32-bit value, as the (X,Y) positions are defined by the reference image voxel matrix.

CCCCC.4 OPHTHALMIC TOMOGRAPHY USE CASE

DICOM Height Map Segmentation is intended to be applicable to a broad variety of imaging domains, but its initial use case is for segmentation of retinal layer surfaces in ophthalmic tomography (OPT).

OPT generally creates multi-frame images with frames that are nominally perpendicular to the retinal surface, which is treated as if it were a flat baseline coronal plane for image rendering (see PS3.3 Section A.52.4.3.1).

When OPT scans are acquired in a regular set of closely spaced rasters, they represent a complete volume and are characterized with the Ophthalmic Volumetric Properties Flag (0022,1622) value YES. This use may also typically have Scan Pattern Type Code Sequence (0022,1618) value (128279, DCM, “Cube B-scan pattern”). In this case, the height map segmentation for each surface may be a 2-D frame orthogonal to the OPT scan frames, and is analogous to an Ophthalmic Thickness Map image or a Corneal Topography Map image (which is also a type of height map). There will thus be one 2-D Height Map Segmentation frame for each segmented surface layer.

However, OPT scans may not be volumetric (see CID 4272 Opt Scan Pattern Type for non-cube patterns). In that case, the segmented surface layer in each OPT frame will have a corresponding Height Map Segmentation frame consisting of a single row. Each layer, i.e., segment, within a Height Map Segmentation SOP Instance may therefore be specified by a set of 1-D frames.

Height Map segmentations of OPT (or other) images may be used in a number of follow-on applications. The surfaces may be overlaid on renderings of the source images, or they may be used to select data to be further processed, e.g., to create en face images of individual retinal layers.