Correction Number CP-2213

Log Summary: Sub-pixel Resolution SCOORD mapping to 3D RCS

Name of Standard
PS3.3

Rationale for Correction:

SCOORD image-relative coordinates are sub-pixel resolution, but the equation introduced in Sup 73 (registration) explaining image-relative coordinate mapping to the 3D reference coordinate system describes whole pixel not sub-pixel mapping, and is misleading.

Further, the existing equation describes an input of [whole] row and column indices that start with zero, when normative descriptions of Attributes that reference entire pixels use indices that start from one (e.g., those affected by Bounding Box Annotation Units for PIXEL and MATRIX).

Clarify, add a note about whole/entire pixel index origin being zero or one, and add an equation illustrating the necessary scaling and translation.

Also, allow the MATRIX value of Bounding Box Annotation Units and the VOLUME value of Pixel Origin Interpretation to refer to any tiled image, not just Whole Slide Microscopy images (e.g., to apply to parametric maps, which may be tiled per CP 1984).

Add a figure to illustrate the MATRIX sub-pixel coordinate addressing.

Correction Wording:
Amend PS3.3 as follows:

C.7.6.2.1.1 Image Position and Image Orientation

... 

The Image Plane Attributes, in conjunction with the Pixel Spacing Attribute, describe the position and orientation of the image slices relative to the Patient-Based Coordinate System. In each image frame Image Position (Patient) (0020,0032) specifies the origin of the image with respect to the Patient-Based Coordinate System. RCS and Image Orientation (Patient) (0020,0037) values specify the orientation of the image frame rows and columns.

The mapping of an integer (entire) pixel location (i,j) to the RCS is calculated as follows:

\[
\begin{bmatrix}
P_x \\
P_y \\
P_z \\
1
\end{bmatrix}
= 
\begin{bmatrix}
X_x \Delta_i Y_x \Delta_j 0 S_x & i \\
X_y \Delta_i Y_y \Delta_j 0 S_y & j \\
X_z \Delta_i Y_z \Delta_j 0 S_z & 0 \\
0 0 0 1
\end{bmatrix} \cdot
\begin{bmatrix}
i \\
j \\
0 \\
1
\end{bmatrix}
\]  

(C7621-1)

Where:

- \(P_{xyz}\) The coordinates of the voxel (i,j) in the frame's image plane in units of mm.
- \(S_{xyz}\) The three values of Image Position (Patient) (0020,0032). It is the location in mm from the origin of the RCS.
- \(X_{xyz}\) The values from the row (X) direction cosine of Image Orientation (Patient) (0020,0037).
- \(Y_{xyz}\) The values from the column (Y) direction cosine of Image Orientation (Patient) (0020,0037).

\(i\) Column integer index to the image plane. The first (entire) column is index zero.

\(j\) Row integer index to the image plane. The first (entire) row index is zero.

\(\Delta_i\) Pixel column resolution of Pixel Spacing (0028,0030) in units of mm.

\(\Delta_j\) Row pixel resolution of Pixel Spacing (0028,0030) in units of mm.

Note

Integer entire row and column indices (i,j) as input to this equation start from zero, which is a common mathematical convention. Many DICOM Attributes define indices as starting from one, e.g., those affected by Bounding Box Annotation Units (0070,0003) for PIXEL and MATRIX in Section C.10.5 Graphic Annotation Module. This needs to be accounted for when applying this equation literally.

Insert the following text in PS3.3 C.7.6.2.1.1 after the description of Equation C.7.6.2.1-1 parameters:

The mapping of a sub-pixel resolution image or total pixel matrix relative location (c,r), such as used in Spatial Coordinates Macro, to the RCS is calculated as follows:

\[
\begin{bmatrix}
P_x \\
P_y \\
P_z \\
1
\end{bmatrix}
= 
\begin{bmatrix}
X_x \Delta_c Y_x \Delta_r 0 S_x & c \\
X_y \Delta_c Y_y \Delta_r 0 S_y & 0 1 0 -.5 \\
X_z \Delta_c Y_z \Delta_r 0 S_z & 0 0 1 0 \\
0 0 0 1
\end{bmatrix} \cdot
\begin{bmatrix}
c \\
r \\
0 \\
1
\end{bmatrix}
\]  

(C7621-2)

Where:

- \(P_{xyz}\) The coordinates of the voxel (c,r) in the frame's image plane in units of mm.
- \(S_{xyz}\) The three values of Image Position (Patient) (0020,0032). It is the location in mm from the origin of the RCS.
- \(X_{xyz}\) The values from the row (X) direction cosine of Image Orientation (Patient) (0020,0037).
The values from the column (Y) direction cosine of Image Orientation (Patient) (0020,0037).

Column sub-pixel resolution index to the image plane. The left pixel edge of the first column of the frame or total pixel matrix is index zero.

Column pixel resolution of Pixel Spacing (0028,0030) in units of mm.

Row sub-pixel resolution index to the image plane. The top pixel edge of the first row of the frame or total pixel matrix index is zero.

Row pixel resolution of Pixel Spacing (0028,0030) in units of mm.

## C.10.5 Graphic Annotation Module

### Table C.10-5. Graphic Annotation Module Attributes

<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>Tag</th>
<th>Type</th>
<th>Attribute Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graphic Annotation Sequence</td>
<td>(0070,0001)</td>
<td>1</td>
<td>A Sequence of Items each of which represents a group of annotations composed of graphics or text or both. One or more Items shall be included in this Sequence.</td>
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</table>

### Enumerated Values:

- **PIXEL**: Image relative position specified with sub-pixel resolution such that the origin, which is 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 Columns/Rows (see Figure C.10.5-1). The values must be within the range 0.0 to Columns/Rows.

- **DISPLAY**: Fraction of Specified Displayed Area where 0.0/0.0 is the TLHC and 1.0/1.0 is the BRHC. The values must be within the range 0.0 to 1.0.

- **MATRIX**: Image relative position specified with sub-pixel resolution such that the origin, which is at the Top Left Hand Corner (TLHC) of the TLHC pixel of the Total Pixel Matrix, 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 of the Total Pixel Matrix is Total Pixel Matrix Columns/Total Pixel Matrix Rows (see Figure C.10.5-1b). The values must be within the range 0.0/0.0 to Total Pixel Matrix Columns/Total Pixel Matrix Rows. MATRIX may be used only if the value of Referenced SOP Class UID (0008,1150) within instance referenced by Referenced Image Sequence (0008,1140) is \(1.2.840.10008.5.1.4.1.1.77.1.6\) (VL Whole Slide Microscopy Image) tiled (i.e., contains Total Pixel Matrix Columns and Total Pixel Matrix Rows).

Required if Bounding Box Top Left Hand Corner (0070,0010) or Bounding Box Bottom Right Hand Corner (0070,0011) is present.

### C.10.5.1 Graphic Annotation Attribute Descriptions

#### C.10.5.1.1 Graphic Data and Graphic Type

Graphic Data (0070,0022) contains the points in the graphic annotation, each dimension for the first point, followed by dimensions for second point, etc. For a two dimensional curve: X1, Y1, X2, Y2, etc. The first (X) dimension corresponds to the image or Specified...
Displayed Area column (horizontal offset), and the second (Y) dimension corresponds to the image or Specified Displayed Area row (vertical offset). The Value Representation of all components of the N-tuple shall be the same. The image or Specified Displayed Area relative drawing space is defined in Graphic Annotation Units (0070,0005).

Figure C.10.5-1. Sub-pixel Addressing Units in PIXEL Space

Insert new figure:

Figure C.10.5-1b. Sub-pixel Addressing Units in MATRIX Space
### C.18.6 Spatial Coordinates Macro

#### Table C.18.6-1. Spatial Coordinates Macro Attributes

<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>Tag</th>
<th>Type</th>
<th>Attribute Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graphic Data</td>
<td>(0070,0022)</td>
<td>1</td>
<td>An ordered set of (column,row) pairs that denote positions in an image specified with sub-pixel resolution such that the origin at the TLHC of the TLHC pixel is 0.0/0.0, the BRHC of the TLHC pixel is 1.0/1.0, and the BRHC of the BRHC pixel is Columns/Rows. The values must be within the range 0/0 to Columns/Rows. The maximum values are those contained in the referenced image in Attributes Columns (0028,0011) and Rows (0028,0010), or in the case of spatial coordinates with Pixel Origin Interpretation (0048,0301) value VOLUME, in Attributes Total Pixel Matrix Columns (0048,0006) and Total Pixel Matrix Rows (0048,0007). See Section C.18.6.1.1 for further explanation.</td>
</tr>
<tr>
<td>Pixel Origin Interpretation</td>
<td>(0048,0301)</td>
<td>1C</td>
<td>For a referenced multi-frame image, specifies whether the Graphic Data (0070,0022) values are to be interpreted relative to the individual frame pixel origins, or relative to the Total Pixel Matrix origin. Required if the value of Referenced SOP Class UID (0008,1150) referenced by Referenced Image Sequence (0008,1140) is 1.2.840.10008.5.1.4.1.77.1.6 (VL Whole Slide Microscopy Image) tiled (i.e., contains Total Pixel Matrix Columns and Total Pixel Matrix Rows). May be present otherwise. Enumerated Values: FRAME relative to individual frame VOLUME relative to Total ImagePixel Matrix. If not present, Graphic Data values are defined relative to the frame pixel origin.</td>
</tr>
</tbody>
</table>

#### C.18.6.1 Spatial Coordinates Macro Attribute Descriptions

##### C.18.6.1.1 Graphic Data

Graphic Data may be used to associate an anatomic or spatial Concept with a defined subset of one or more images. Graphic Data may be explicitly defined as a single point (i.e., to denote the epicenter of an anatomic site or lesion) or more than one point (i.e., representing a set of points or an open or closed polygon).

**Note**

Spatial coordinates may be used to associate observational data with a set of Image features. Spatial coordinates also may be used to convey coordinates that are input data for a measurement.

### C.10.4 Displayed Area Module

#### Table C.10-4. Displayed Area Module Attributes

<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>Tag</th>
<th>Type</th>
<th>Attribute Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displayed Area Selection</td>
<td>(0070,005A)</td>
<td>1</td>
<td>A Sequence of Items each of which describes the displayed area selection for a group of images or frames. Sufficient Items shall be present to describe every image and frame listed in the ???. One or more Items shall be included in this Sequence.</td>
</tr>
<tr>
<td>Attribute Name</td>
<td>Tag</td>
<td>Type</td>
<td>Attribute Description</td>
</tr>
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<tr>
<td></td>
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<td></td>
<td>For a referenced multi-frame image, specifies whether the Displayed Area Top Left Hand Corner (0070,0052) and Displayed Area Bottom Right Hand Corner (0070,0053) are to be interpreted relative to the individual frame pixel origins, or relative to the Total Pixel Matrix origin (see ???). Required if the value of Referenced SOP Class UID (0008,1150) within instance referenced by Referenced Image Sequence (0008,1140) is 1.2.840.10008.5.1.4.1.77.1.6 (VL Whole Slide Microscopy image) tiled (i.e., contains Total Pixel Matrix Columns and Total Pixel Matrix Rows). May be present otherwise. Enumerated Values: FRAME relative to individual frame VOLUME relative to Total Image Pixel Matrix If not present, TLHC and BRHC are defined relative to the frame pixel origins.</td>
</tr>
<tr>
<td>&gt;Pixel Origin Interpretation</td>
<td>(0048,0301)</td>
<td>1C</td>
<td>The top left (after spatial transformation) pixel in the referenced image to be displayed, given as column/row. Column is the horizontal (before spatial transformation) offset (X) and row is the vertical (before spatial transformation) offset (Y) relative to the origin of the pixel data before spatial transformation, which is 1/1. See Figure C.10.4-1.</td>
</tr>
<tr>
<td>&gt;Displayed Area Top Left Hand Corner</td>
<td>(0070,0052)</td>
<td>1</td>
<td>The bottom right (after spatial transformation) pixel in the referenced image to be displayed, given as column/row. Column is the horizontal (before spatial transformation) offset (X) and row is the vertical (before spatial transformation) offset (Y) relative to the origin of the pixel data before spatial transformation, which is 1/1. See Figure C.10.4-1.</td>
</tr>
</tbody>
</table>
Figure C.10.4-1. Example of Displayed Area Selection Addressing of Pixels Before and After Spatial Transformation