## DICOM Correction Proposal

<table>
<thead>
<tr>
<th>Status</th>
<th>Letter Ballot</th>
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</thead>
<tbody>
<tr>
<td>Date of Last Update</td>
<td>2019/05/24</td>
</tr>
<tr>
<td>Person Assigned</td>
<td>Wim Corbijn</td>
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<td>Submitter Name</td>
<td>Wim Corbijn</td>
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<tr>
<td>Submission Date</td>
<td>2018/11/23</td>
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<tr>
<td>Correction Number</td>
<td>CP-1880</td>
</tr>
<tr>
<td>Log Summary</td>
<td>Update Linear, Exact and Sigmoid formula</td>
</tr>
<tr>
<td>Name of Standard</td>
<td>PS3.3</td>
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<tr>
<td>Rationale For Correction:</td>
<td>The else part of the following formula seems not correct as it will not result in range of ymin to ymax if you take the boundary values x=c-w/2 and x=c+w/2. If (x &lt;= c - w/2), then y = ymin else if (x &gt; c + w/2), then y = ymax else y = (x - c) / w * (ymax - ymin) + ymin. The SIGMOID function is missing the part to fit the y-min to y-max range. Current function only is working when y-min is 0. This makes the Output range equal to y-max as is described in the note. When y-min is not 0 the formula is incorrect as then y-max is then not the same as the total Range to be covered, which shall be (y-max – y-min). In that case also lowest value shall be y-min, meaning after the multiplication y-min should be added. Not sure why the structure of mapping to y-min to y-max is not used here, seems the note is in that sense not relevant or also applies to the other two methods. Formula: $y = \frac{(y_{max} - y_{min})}{1 + \exp\left(-4 \cdot \frac{x - WC}{WW}\right)} + y_{min}$</td>
</tr>
<tr>
<td>Correction Wording:</td>
<td>Item #1: update PS3.3 Section C.11.2.1.3.1 SIGMOID Function</td>
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### C.11.2.1.3.1 SIGMOID Function

If the value of VOI LUT Function (0028,1056) is SIGMOID, the function to be used to convert the output of the (conceptual) Modality LUT values to the input of the (conceptual) Presentation LUT is given by

$$\text{LUT} = -\frac{\text{Output range}}{1 + \exp\left(-4 \cdot \frac{L - WC}{WW}\right)}$$

Commented [CvWW1]: Replace formula with new formula or with text as shown.
\[ y = \frac{(y_{\text{max}} - y_{\min})}{\left(1 + \exp\left(-4 \times \frac{x - WC}{WW}\right)\right)} + y_{\min} \]

where

\( \text{INX} \) is the input value of the LUT (i.e., the output of the (conceptual) Modality LUT).

\( WC \) is the Window Center defined interactively by the user or by using the values provided in (0028,1050).

\( WW \) is the Window Width defined interactively by the user or by using the values provided in (0028,1051).

\( y \) is the output value.

\( y_{\text{min}} \) is the minimum output value.

\( y_{\text{max}} \) is the maximum output value (see Note below on encoding depth).

Window Width (0028,1051) shall always be greater than 0.

Note

1. The encoding depth of the input values for the VOI LUT function is given by the number of bits specified in Bits Stored (0028,0101). The output values of the VOI LUT function must be encoded with an appropriate depth to be then used as input for the Presentation LUT (typically this value is 8 bits) and the Output range parameter allows this scaling. Moreover, Equation C.11.1 is given assuming float values for clarity but the actual implementation must include rounding to output integer values.

Window Width (0028,1051) is required to be greater than zero to prevent division by zero (quite apart from being meaningless).

**Item #2: update PS3.3 Section C.11.2.1.3.2 LINEAR_EXACT Function**

**C.11.2.1.3.2 LINEAR_EXACT Function**

If the value of VOI LUT Function (0028,1056) is LINEAR_EXACT, the function to be used to convert the output of the (conceptual) Modality LUT values to the input of the (conceptual) Presentation LUT is given by the following pseudo-code, where \( x \) is the input value, \( y \) is an output value with a range from \( y_{\text{min}} \) to \( y_{\text{max}} \), \( c \) is Window Center (0028,1050) and \( w \) is Window Width (0028,1051):

\[
\begin{align*}
\text{if } (x \leq c - w/2), & \text{ then } y = y_{\text{min}} \\
\text{else if } (x > c + w/2), & \text{ then } y = y_{\text{max}} \\
\text{else } y &= \left(\frac{(x - c)}{w} + 0.5\right) \times (y_{\text{max}} - y_{\text{min}}) + y_{\text{min}}
\end{align*}
\]

Window Width (0028,1051) shall always be greater than 0.

Note

1. For example, given stored unsigned pixel values from 0 to 65535, a Rescale Intercept of 0 and a Rescale Slope of 1.0/65535, a Window Width of 1.0 and a Window Center of 0.5 would specify the entire range of values (the identity transformation for those rescale values).

2. Window Width (0028,1051) is required to be greater than zero to prevent division by zero (quite apart from being meaningless).