

DICOM Correction Proposal

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Correction Number	CP 1949
Log Summary:	Specify the identity window level values
Name of Standard	PS3.3 2019e
Rationale for Correction:	<p>The note for the identity window level may be confusing with respect to alternative interpretations of what "identity" means.</p> <p>In this context, "identity" was intended to refer only to "mathematical identity", and not to the case where there is a desire to select the full range of the pixel values actually used, rather than the full range of possible pixel values.</p> <p>For example, a CR image might be defined over a 12 bit unsigned integer theoretical range of possible values, where 0=absolutely no radiation detected, and 4095=radiation detected in a hard vacuum at minimum distance to the x-ray emitter at maximum time. However, real-world actual CR images, which might have a minimum value of, say 10, and a maximum value of, say 1009 at a particular range, given that it is in air, and has some amount of distance for a body part to get in the way of the radiation (this is on a particular exposure). Choosing a mathematical "identity" window level of $2^{12} / 2^{11}$ as suggested in note 4 would result in a display with less contrast (as described in note 7) than a window that selected only the actually used pixel values.</p> <p>Extend note 4 to clarify the meaning of identity and address the matter of the full range of pixel values used.</p>
Correction Wording:	

Update PS3.3 C.11.2.1.2.1 (note 4) as follows

C.11.2.1.2.1 Default LINEAR Function

If VOI LUT Function (0028,1056) is absent or has a value of LINEAR, Window Center (0028,1050) and Window Width (0028,1051) specify a linear conversion from stored pixel values (after any Modality LUT or Rescale Slope and Intercept specified in the IOD have been applied) to values to be displayed. Window Center contains the input value that is the center of the window. Window Width contains the width of the window.

Note

The terms "window center" and "window width" are not consistently used in practice, nor were they defined in previous editions of the Standard. The definitions here are presented for the purpose of defining consistent meanings for identity and threshold transformations while preserving the common practice of using integer values for center and width.

Window Width (0028,1051) shall always be greater than or equal to 1.

When Window Width (0028,1051) is greater than 1, these Attributes select the range of input values that are to be mapped to the full range of the displayed output.

When Window Width (0028,1051) is equal to 1, they specify a threshold below which input values will be displayed as the minimum output value.

Note

Whether the minimum output value is rendered as black or white may depend on the value of Photometric Interpretation (0028,0004) or the presence of a Presentation LUT Module.

These Attributes are applied according to the following pseudo-code, where x is the input value, y is an output value with a range from y_{min} to y_{max} , c is Window Center (0028,1050) and w is Window Width (0028,1051):

```
if (x <= c - 0.5 - (w-1) / 2), then y = ymin
else if (x > c - 0.5 + (w-1) / 2), then y = ymax
else y = ((x - (c - 0.5)) / (w-1) + 0.5) * (ymax - ymin) + ymin
```

Note

1. For the purpose of this definition, a floating point calculation without integer truncation is assumed, though the manner of implementation may vary as long as the result is the same.
2. The pseudo-code function computes a continuous value over the output range without any discontinuity at the boundaries. The value of 0 for w is expressly forbidden, and the value of 1 for w does not cause division by zero, since the continuous segment of the function will never be reached for that case.
3. For example, for an output range 0 to 255:

$c=2048, w=4096$ becomes:

```
if (x <= 0) then y = 0
else if (x > 4095) then y = 255
else y = ((x - 2047.5) / 4095 + 0.5) * (255-0) + 0
```

$c=2048, w=1$ becomes:

```
if (x <= 2047.5) then y = 0
else if (x > 2047.5) then y = 255
else /* not reached */
```

$c=0, w=100$ becomes:

```
if (x <= -50) then y = 0
else if (x > 49) then y = 255
else y = ((x + 0.5) / 99 + 0.5) * (255-0) + 0
```

$c=0, w=1$ becomes:

```
if (x <= -0.5) then y = 0
else if (x > -0.5) then y = 255
else /* not reached */
```

4. A Window Center of 2^{n-1} and a Window Width of 2^n selects the range of input values from 0 to 2^n-1 . This represents a mathematical identity VOI LUT transformation over the possible input values (whether used or not) in the case where no Modality LUT is specified and the stored pixel data are n bit unsigned integers.

In the case where x_1 is the lowest input value actually used in the Pixel Data and x_2 is the highest, a Window Center of $(x_1+x_2+1)/2$ and a Window Width of (x_2-x_1+1) selects the range of input values from x_1 to x_2 , which represents the full range of input values present as opposed to possible. This is distinct from the mathematical identity VOI LUT transformation, which instead selects the full range of input values possible as opposed to those actually used. The mathematical identity and full input range transformations are the same when $x_1 = 0$ and x_2 is 2^n-1 and the input values are n bit unsigned integers. See also Note 7.

5. A Window Width of 1 is typically used to represent a "threshold" operation in which those integer input values less than the Window Center are represented as the minimum displayed value and those greater than or equal to the Window Center are represented as the maximum displayed value. A Window Width of 2 will have the same result for integral input values.
6. The application of Window Center (0028,1050) and Window Width (0028,1051) may select a signed input range. There is no implication that this signed input range is clipped to zero.
7. The selected input range may exceed the actual range of the input values, thus effectively "compressing" the contrast range of the displayed data into a narrower band of the available contrast range, and "flattening" the appearance. There are no limits to the maximum value of the window width, or to the minimum or maximum value of window level, both of which may exceed the actual or possible range of input values.
8. Input values "below" the window are displayed as the minimum output value and input values "above" the window are displayed as the maximum output value. This is the common usage of the window operation in medical imaging. There is no provision for an alternative approach in which all values "outside" the window are displayed as the minimum output value.
9. The output of the Window Center/Width or VOI LUT transformation is either implicitly scaled to the full range of the display device if there is no succeeding transformation defined, or implicitly scaled to the full input range of the succeeding transformation step (such as the Presentation LUT), if present. See Section C.11.6.1.
10. Fractional values of Window Center and Window Width are permitted (since the VR of these Attributes is Decimal String), and though they are not often encountered, applications should be prepared to accept them.