Color Scale Criteria for Skin Dose Map in Fluoroscopy (62b IEC MT41)

*S* is a function mapping *mGy* to *Step*, which is an integer between 0 and 7.

*S*: *mGy* -> *step*, *step* ϵ {0, 1, 2, 3, 4, 5, 6, 7}

*C* (the “color scale”) is a function mapping *Step* to the three-dimensional CIELAB color space.

*C*: *step* -> (*L\*, a\*, b\*)*

(*L\*, a\*, b\**) are the standard symbols for the CIELAB coordinates. *L\** is the *lightness* (similar to the “JND index” concept used in DICOM GSDF). *a\** and *b\** represent the *chromaticity*. *a\** indicates the transition from green to red. *b\** indicates the transition from blue to yellow. Neutral shades have *a\**=0 and *b\**=0.

*h* is the *hue* of (*L\*, a\*, b\*)* defined as the angel formed by (*a\*, b\**), (0, 0), and (*a\*,* 0) on a plane.

*h=arctan(b\*/a\*)*

*G* (the “gray scale”) is a function mapping *Step* to the one-dimensional lightness property CIE *L\**.

*G*: *step* -> (*L\*, 0, 0)*

Notice that it is possible but not required to use the same *L\** projection for both *C* and *G*. In this case, the same image can be used on the same display by switching between color and monochrome mode.

*∆E* is the standard *CIE color difference* between two colors *i* and *j*, calculated as the Euclidean distance between their coordinates (*Li\*, ai\*, bi\** and *Lj\*, aj\*, bj\**) in the CIELAB color space.

*dE*(*Li\*, ai\*, bi\*, Lj\*, aj\*, bj\**) = ((*Li\*-Lj\**)^2+(*ai\*-aj\**)^2 + (*bi\*-bj\**)^2)^0.5

*D\_color* is a (display) function mapping CIELAB to RGB pixel values for a color display (e.g., the *sRGB* color space). *r, g, b* are intergers between 0 and 255 for an 8-bit display.

*D\_color*(*L\*, a\*, b\**) -> (*r, g, b*)

Notice that “RGB” is pixel values with an undefined color space, while “sRGB” is a standard color space with a one-to-one mapping to CIELAB.

*D\_mono* is a (display) function mapping CIELAB to the digital driving level (*ddl*) for a monochrome display (e.g., the DICOM GSDF calibration method).

*D\_mono*(*L\**) -> *ddl*

Objective #1 is to find a function *C* (color scale) that: (1) has a minimum color difference α (e.g., 10 ∆E) between any two consecutive Steps between 0 and 7, and (2) has incremental hue changes from blue to red between Steps 1 and Step 6 with a minimum hue difference β (e.g., 30°).

*dE*(*C*(*i*), *C*(*i*+1)) >= *α, i* ϵ {0, 1, 2, 3, 4, 5, 6}

*h*(*C*(*i*+1)) >= *h*(*C*(*i*)) + β, *i* ϵ {1, 2, 3, 4, 5}

Objective #2 is to find a function *G* (gray scale) that has a minimum color difference α (e.g., 10 ∆E) between any two consecutive Steps between 0 and 7.

for any step *i* ϵ {0, 1, 2, 3, 4, 5, 6}, *dE*(*G*(*i*),*G*(*i*+1)) >= α

The final result will be presented as a lookup table between *mGy* and RGB pixel values:

*D\_color(C(S(mGy))),* for color displays

*D\_mono(G(S(mGy))),* for monochrome displays

The definitions of *D\_color* and *D\_mono*, which are in the device domain, need further discussion independent of the design of the color and gray scales, which is in the perceptual domain.