



a. b.
Figure 7.12 Comparison of linear and curved wedge RCM: a. Linear wedge RCM; b. Curved wedge RCM

7.5 Comparison of RCMs to Existing Techniques

Methods of overcoming the problem of the large dynamic range of DR images were discussed in Chapter 5. Commonly utilised methods for viewing DR images when problems of large dynamic range exist are non-linear LUTs and spatial frequency methods such as unsharp mask filters with large kernel sizes and multi-scale processing.

An example of the use of a non-linear LUT is shown in Figure 7.13. The LUT used for the operation can be seen on the left of the image. In this example, the displayed contrast of the thoracic spine has been adjusted to optimise the contrast for the entire length of the spine. The disadvantage of this method is that the LUT is applied globally. Its effects cannot be fully controlled by the user in all local anatomical regions within the image.

As discussed in Chapter 5, many researchers have endeavoured to find alternative methods to the use of LUTs for dynamic range control. One such method is the unsharp mask filter. An unsharp mask filter of kernel size of 109x109 has been applied to images of both feet in Figure 7.14b. A linear wedge RCM, with a profile height of 3.2, has also been applied to the original image prior to application of the unsharp mask. This image can be seen in Figure 7.14a. In this example, the effect of dynamic range compression is very similar between the two images.



Figures 7.13 Thoracic spine displayed using a non-linear LUT. The LUT is seen on the left

Enlarged sections of these two images can be seen in Figures 7.15a & b. The edge enhancement effect of the unsharp mask in Figure 7.15b is evident. The application of a RCM to the original image, seen in Figure 7.15a, has not spatially enhanced the image. Following the application of a RCM to gain the benefits of dynamic range compression, spatial enhancement effects may be applied if desired. The disadvantage of using unsharp mask methods for dynamic range compression is that spatial enhancement is an inherent effect of the method and may not be desired in all circumstances.



a. b.
Figure 7.14 Comparison of linear RCM and unsharp mask: a. Linear wedge RCM; b. Unsharp mask filter, size 109x109

According to Vuylsteke & Schoeters (1999), the multi-scale approach to dynamic range control is preferred to the unsharp mask method. Images of a foot phantom comparing the multi-scale approach to the use of a linear wedge RCM can be seen in Figures 7.16a, b & c.

A single computed radiographic image of a foot phantom (3M Company, St. Paul, USA) was obtained. The image was acquired on an ADC Solo (Agfa-Gevaert, Nunawading) computed radiographic unit and was processed using the multi-scale image contrast amplification (MUSICA) functions available through the IPD viewer software (Agfa-Gevaert, Nunawading).

Figure 7.16a is the original unprocessed image of the foot phantom. Radiographic contrast and brightness have been adjusted for optimal viewing of the metatarsal and phalangeal regions of the image. The image in Figure 7.16b has had the default MUSICA factors for an image of a foot applied. These factors were:

Table 7.9 MUSICA factors – foot phantom (Figure 7.16b)

MUSICA factors (Figure 7.16a)
MUSI Factor = 2.0
Latitude Reduction = 2.0
Edge Contrast = 0
Noise Reduction = 0

A wedge RCM has been applied to the original image and is seen in Figure 7.16c. The wedge RCM factors are shown in Table 7.10.

Table 7.10 User selectable factors of wedge RCM – foot phantom (Figure 7.16c)

User selectable factors (Figure 7.16c)
curved or linear: linear
end vector lengths (%) non-enhanced: 0 enhanced: 0
rotation: 180°
profile height: 3.0

Both the multi-scale approach and the application of a RCM have improved the dynamic range of the image. This is visualised as improved contrast and brightness in the ankle region of Figures 7.16b & c respectively.

Enlarged sections of the metatarsal region of Figures 7.16a, b & c can be seen in Figures 7.17a, b & c respectively. The MUSICA image displays changes in spatial appearance compared to the original image. No such changes are visualised in image where the RCM was applied. The spatial edge enhancement seen in Figure 7.17b is not as apparent as that which resulted from the use of an unsharp mask in Figure 7.15b.

The use of an appropriate RCM can achieve similar dynamic range compression effects to those obtained by MUSICA in an image. The MUSICA process, however, alters the spatial appearance of the image. This effect is inherent in the MUSICA process and may or may not be desirable in the image. The use of a RCM does not result in spatial changes in the image. Spatial enhancement methods used for dynamic range control, as discussed in Chapter 5, introduce noise into the image. Objective analysis and comparison of images modified by the MUSICA process and the RCM method are detailed in Chapter 8.