2016bihistogramequalizationtwo plateau limits (BHE2PL)

Estudar o parágrafo "**4 Proposed method**"

4 Proposed method

The idea of the new method of equalization is to use a total of four plateau limits, two plateau limits for each sub-histogram instead of the six plateau limits used in [6], three plateau limits for each sub-histogram.With the removal of these two limits what we want to achieve is to reduce the brightness difference between the input image and the resulting image, while still achieving an improvement in the image contrast. The proposed method is named bi-histogram equalization using two plateau limits (BHE2PL).

The first step wewould takewould be proceeding to calculate the expected average intensity SP of the global histogram of the image (see Fig. 1) given by the equation:

Equation (8)

Once the SP value has been calculated using Eq. (8), the histogram is split into two sub-histograms, the lower subhistogram *H*L and the upper sub-histogram *H*U. *H*L contains the values of intensities found from the minimum gray level in the image *l*MIN up to the average intensity SP, while *H*U

contains the values of intensities found from SP + 1 up the maximum gray level in the image *l*MAX (see Fig. 2). *l*MIN is the lowest effective intensity within the image, i.e., the lowest intensity in the histogram that appears at least once in the image, likewise *l*MAX represents the maximum effective intensity found in the image, i.e., the highest intensity within the histogram that appears at least once in the image. After the global histogram has been divided, the plateau limits PL's for each resulting sub-histogram are calculated. Basically, each plateau limit is calculated using the following formula:

Equation (9)

where *R* is a coefficient with a value between 0 and 1, and *Pk* represents the peak in the histogram given by:

Equation (10)

In thiswork, the values of the PL'swill be selected using local information obtained from the input histogram. One way to extract information from the input histogram is to use the gray-level ratio GR for each obtained sub-histogram. Since GR is a value between 0 and 1, it replaces *R* in Eq. (9), GR

being the value used to represent the level of improvement that needs to be applied. The lowpercentages of improvement are applied at lowrates of gray, likewise, the high percentages of improvement are applied at high rates of gray. Given the GR's use as coefficients, the plateau limits can be calculated as:
Equation (11) 12-13-14

where *Pk*L is the maximum intensity peak for the lower subhistogram, PLL1 and PLL2 are the lower and upper limits of the lower sub-histogram, likewise *Pk*U is the maximum

intensity peak for the upper sub-histogram, PLU1 and PLU2 are the lower and upper limits of the upper sub-histogram. The gray-level proportions of the lower sub-histogram GRL1 and GRL2, and the gray-level proportions of the upper subhistogram GRU1 and GRU2 are defined as:

Equation (15) 16-17-18

where SPL and SPU are the average intensities of the lower and upper sub-histograms, respectively, *D*L and *D*U are differences in the gray-level proportions of the lower and upper sub-histograms, respectively. SPL and SPU are calculated as:

Equation (19) -20

where *N*L and *N*U are the total number of pixels that are in the sub-histogram of the lower and upper part. *D*L and *D*U are calculated as follows:

Equation (21) -22

Figure 3 shows the histogram with the respective plateau limits found. Thereupon, the shape of the histogram is modified, for the lower sub-histogram *(l*MIN $\leq k \leq$ SP*)*, as follows:

Equation (23)

This means that for values in the lower sub-histogram that are less than or equal to PLL2, the sub-histogram is modified with the PLL1 value, if this value is greater then the value of PLL2 is used.
Likewise for the upper sub-histogram *(*SP + 1 $\leq k \leq$ *l*MAX*)*, the sub-histogram is modified as follows:

Equation (24)

The modified histogram is shown in Fig. 4. Once the histogram modification process is finished each sub-histogram

is equalized independently according to Eq. (6).

The function is given by:

$$f'(k) = X_0 + (X_{L-1} - X_0) \times [c(k) - 0.5 \times p(k)] \qquad (6)$$