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FACULTY OF EGINEERING

Digital Image Processing
LECTURE-11

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OUTLINE

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Transformations of Gray Levels

Linear Transformations of Image Grayscales. A linear transformation of an image is a function that maps each pixel gray level value into another gray level at the same position according to a linear function. The input (argument) is a gray level $f = f(m,n)$ at location (m,n) and the output is a new gray level $g = g(m,n)$ defined at the same position (m,n). Linear mappings have the form $g(m,n) = T[f(m,n)]$ such that

$$T[af(m,n) + bf(j,k)] = ag(m,n) + bg(j,k)$$

However, affine transformations are more useful and they are just a linear transformation followed by a translation, such as the equation of a line, $y = ax + b$, where a is the slope and b is the y-intercept. These are often called linear and so we will also. For images gray level transformations these take the form

$$g(m,n) = af(m,n) + b$$

Nonlinear Transformations

1. **Logarithmic Transformations:** A nonlinear transformation is usually done after a linear transformation has set the contrast and range of gray levels to that desired. It maps small equal intervals into nonequal intervals. Suppose that most of the pixels have values at the lower end of the gray scale and we want to spread them out to see the detail there, but that we don't care about the brighter values in the upper range of grays. Then we want a small input interval at the low end to map to a larger interval at the low end for the output image. We also want 0 to map to 0 and 255 to map to 255. The function

$$g(m,n) = (c)\log(f(m,n) + 1)$$

spreads out the lower gray levels. It must map 0 to 0, and $(c)\log(1) = 0$ does this. It also must map 255 to 255, 2 2 so that $255 = (c)\log(255 + 1) = (c)\log(256) = 8c$. Thus $c = 255/8 = 31.875$, so we have

$$g(m,n) = (31.875)\log(f(m,n) + 1)$$

this type of mapping. For example, 128 maps to $31.875\log(128 + 1)$. $(31.875)(7.001) = 223.157$, which is truncated to the integer 223. Thus the gray levels from 0 to 128 are dilated (more strongly at the lower end). We can also use

$$g(m,n) = (c)\log(af(m,n) + 1) \quad (2.6c)$$

where $a > 0$ is a constant and $b > 1$ is a logarithm base.

Exponential Transformations

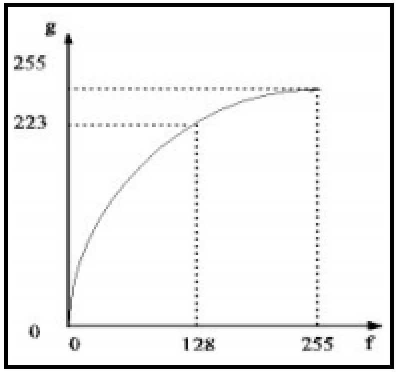
2. Exponential Transformations: Here we are interested in spreading out the upper gray levels at the expense of the lower gray levels, which must be contracted. Again, we want the end points to map to end points. While a logarithmic function spreads out lower levels disproportionately, an exponential spreads out the upper levels disproportionately. If we use

$$g(m,n) = \exp[af(m,n)] - 1$$

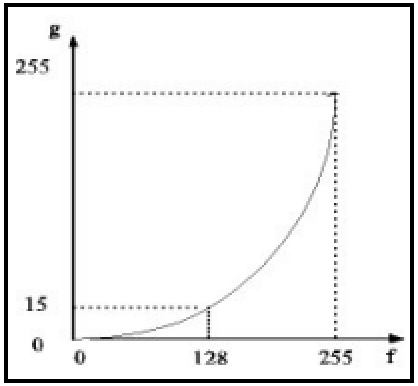
then 0 maps into exp(0) - 1 = 0. To force 255 to map into 255, we ust have that 255 = exp[a(255)] - 1, so that 256 = exp(255a). Upon taking the natural logarithm of each side, we obtain ln(256) = 255a, or a = ln(256)/255 = 0.0217458. Then this mapping is

$$g(m,n) = \exp[0.021746f(m,n)] - 1$$

Logarithmic Transformations and Exponential Transformations



Logarithmic Transformations



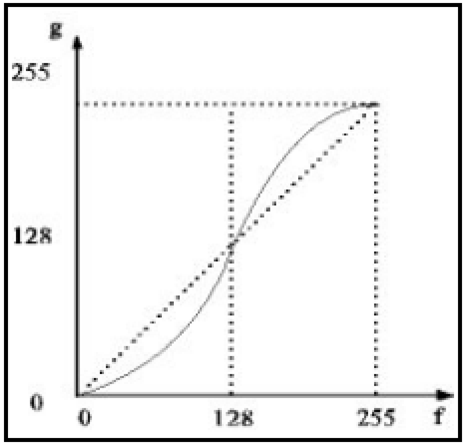
Exponential Transformations

Sigmoid Transformations

Sigmoid Transformations: To stretch the middle gray levels we use a sigmoid function as shown in Figure 2.5, where the gray levels are standardized (0 # f(m,n) # 1) by dividing the f(m,n) by 255. Thus we must scale the outputs by 255.

$$g(m,n) = 255 / \{1.0 + \exp[-a(f(m,n) - b)]\}, \qquad 0 < f(m,n) \# 1 \quad (2.8)$$

where b = 128 is the usual value and a is the rate that defines the steepness of the curve (a =1 is mild whereas a = 3.8 is rather steep).



MCQ

1. Region of Interest (ROI) operations is commonly called as ___________

   a) Shading correction

   b) Masking

   c) Dilation

   d) None of the Mentioned

2. If every element of a set A is also an element of a set B, then A is said to be a _________ of set B.

   a) Disjoint set

   b) Union

   c) Subset

   d) Complement set

3. Consider two regions A and B composed of foreground pixels. The ________ of these two sets is the set of elements belonging to set A or set B or both.

   a) OR

   b) AND

   c) NOT

   d) XOR

MCQ

4. Imaging systems having physical artefacts embedded in the imaging sensors produce a set of points called ___________

   a) Tie Points

   b) Control Points

   c) Reseau Marks

   d) None of the Mentioned

5. Image processing approaches operating directly on pixels of input image work directly in _____________

   a) Transform domain

   b) Spatial domain

   c) Inverse transformation

   d) None of the Mentioned

References

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