IMAGE PROCESSING

Image Analysis

Ch2 – part 2

Image Algebra

There are two primary categories of algebraic operations applied to image:

1. Arithmetic operations.
2. Logic operations.

Addition, subtraction, division and multiplications comprise the arithmetic operations, while AND, OR and NOT make up the logic operations. These operations which require only one image, and are done on a pixel by pixel basis.

To apply the arithmetic operations to two images, we simply operate on corresponding pixel values. For example to add image i1and i2to create i3 :

Arithmetic operations

$$\begin{pmatrix} 3 & 4 & 7 \\ 3 & 4 & 5 \\ 2 & 4 & 6 \end{pmatrix} + \begin{pmatrix} 6 & 6 & 6 \\ 4 & 2 & 6 \\ 3 & 5 & 5 \end{pmatrix} = \begin{pmatrix} 3+6 & 4+6 & 7+6 \\ 3+4 & 4+2 & 5+6 \\ 2+3 & 4+5 & 6+5 \end{pmatrix} = \begin{pmatrix} 9 & 10 & 13 \\ 7 & 6 & 11 \\ 5 & 9 & 11 \end{pmatrix}$$

I_1 I_2 I_1+I_2 I_3

Addition is used to combine the information in two images. Applications include development of image restoration algorithm for molding additive noise, and special effects, such as image morphing in motion pictures.

Image1 Image2 Image1 + Image2

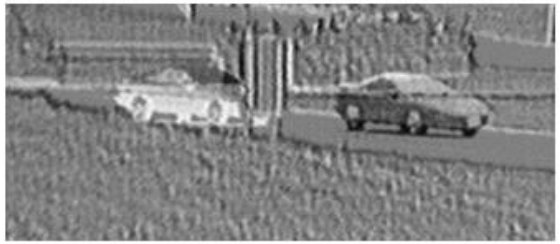
Arithmetic operations

Subtraction of two images is often used to detect motion consider the case where nothing has changed in a sense; the image resulting from subtraction of two sequential image is filled with zero-a black image. If something has moved in the scene, subtraction produces a nonzero result at the location of movement. Applications include Object tracking, Medical imaging, Law enforcement and Military applications.

a. Original scene

b. Same scene later

c. Subtraction of scene **a** from scene **b**



Arithmetic operations

Multiplication and Division are used to adjust the brightness of an image. One image typically consists of a constant number greater than one. Multiplication of the pixel values by a number greater than one will darken the image (Brightness adjustment is often used as a processing step in image enhancement).

Image1

Image2

Image1 * Image2

Original image

Image divided by value<1

Image divided by value>1

Logical operations

apply only to binary images, whereas arithmetic operations apply to multi-valued pixels. Logical operations are basic tools in binary image processing, where they are used for tasks such as masking, feature detection, and shape analysis. Logical operations on entire image are performed pixel–by–pixel. Because the AND operation of two binary variablesis1only when both variables are 1, the result at any location in a resulting AND image is1 only if the corresponding pixels in the two input images are 1. As logical operation involve only one pixel location at a time, they can be done in place, as in the case of arithmetic operations .The XOR (exclusive OR) operation yields a 1 when one or other pixel (but not both) is 1,and it yields a 0 otherwise. The operation is unlike the OR operation, whichis1, when one or the other pixel is 1, or both pixels are 1.

Logical operations

X	Y	AND	OR	XOR
1	1	1	1	0
1	0	0	1	1
0	1	0	1	1
0	0	0	0	0

Logical AND &OR operations are useful for the masking and compositing of images .For example, if we compute the AND of a binary image with some other image, then pixels for which the corresponding value in the binary image is 1 will be preserved, but pixels for which the corresponding binary value is 0 will be set to 0(erased).Thus the binary image acts as a “mask” that removes information from certain parts of the image.

Logical operations

On the other hand, if we compute the XOR of a binary image with some other image, the pixels for which the corresponding value in the binary image is 0 will be preserved, but pixels for which the corresponding binary value is 1, will be set to 1(cleared).

So, masking is a simple method to extract a region of interest (ROI) from an image.

Original Image

Image Mask for AND

Resulting Image with AND

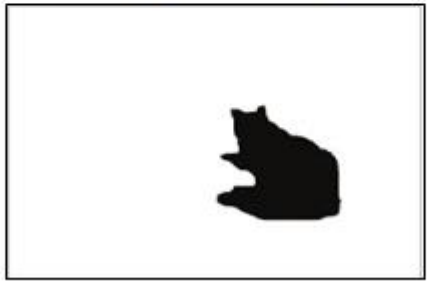
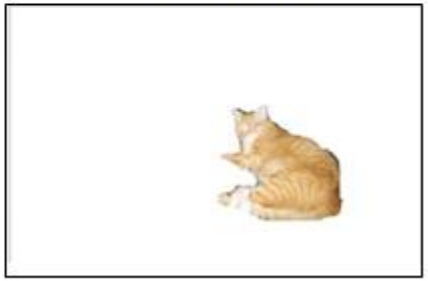


Image Mask for XOR



Resulting Image with XOR

Image Restoration

Image restoration methods are used to improve the appearance of an image by application of a restoration process that use mathematical model for image degradation.

The reasons for deterioration of the images are different and can be seen below:

1. Blurring caused by motion or atmospheric disturbance.
2. Geometrics distortion caused by imperfect lenses.
3. Superimposed interface patterns caused by mechanical systems.
4. Noise from electronic source or Electromagnetic noise.

Image Noise

Noise is any undesired information that contaminates an image. Noise appears in image from a variety of source. The digital image a acquisition process, which converts an optical image into a continuous electrical signal that is then sampled is the primary process by which noise appears in digital images.

At every step in the process there are fluctuations caused by natural phenomena that add a random value to exact brightness value for a given pixel. In typical image the noise can be modeled with one of the following distribution:

1. Gaussian (“normal”) distribution.
2. Uniform distribution.
3. Salt _and _pepper (S&P) distribution.

Noise Removal Using Spatial Filters

Spatial filters can be effectively used to remove various types of noise in digital images and Perform some type of image enhancement.. These spatial filters typically operate on small neighborhoods 3*3 to 11*11, and some can be implemented as convolution masks.

There are three primary categories of spatial filters

1. Mean filters
2. Median filters (order filter)
3. Enhancement filters

Original Image

Image with S&P Noise

Image Denoising

Noise Removal Using Spatial Filters

Mean and median filters are used primarily to conceal or remove noise, although they may also be used for special applications. For instance, a mean filter adds "softer" look to an image. The enhancement filter high lights edges and details within the image.

Spatial filters are implemented with convolution masks. Because convolution mask operation provides a result that is weighted sum of the values of a pixel and its neighbors, it is called a linear filter.

Noise Removal Using Spatial Filters

Overall effects the convolution mask can be predicated based on the general pattern. For example:

- If the coefficients of the mask sum to one, the average brightness of the image will be retained.
- If the coefficients of the mask sum to zero, the average brightness will be lost and will return a dark image.
- If the coefficients of the mask are alternatively positive and negative, the mask is a filter that returns edge information only.
- If the coefficients of the mask are all positive, it is a filter that will blur the image.