Topic 3: Lectures 4 and 5: Some Basic Operations on Images

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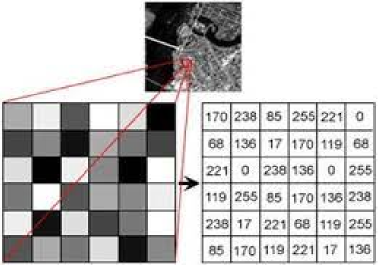
Overview

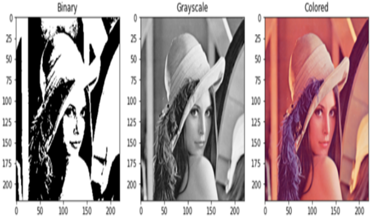
1. Types of Images
2. Types of Low Level Image Processing
   - Spatial Domain Processing
     - Point Processing
     - Neighbourhood Processing
   - Transformed Domain Processing
   - Arithmetic operation, considering image as function
3. Acknowledgements

Types of Images

colour

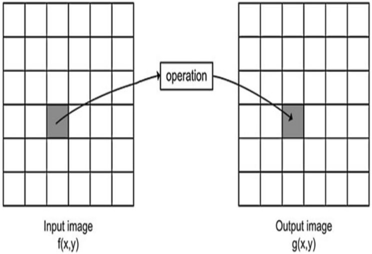
- Binary Image: Binary Matrix
- Gray scale Image: Matrix with integers from 0 to (L-1)
- Colour Image: (M_R, M_G, M_B)
  - M_R is matrix with integers from 0 to (L-1), representing intensity of red colour
  - M_G is matrix with integers from 0 to (L-1), representing intensity of red colour
  - M_B is matrix with integers from 0 to (L-1), representing intensity of red

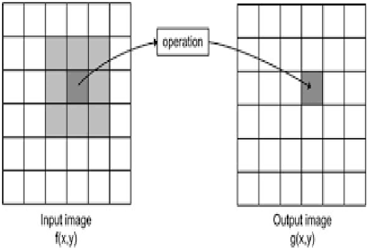




Types of Low Level Image Processing

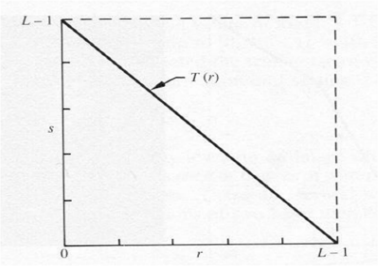
- Spatial Domain
  - Point Processing
  - Neighbourhood Processing
- Transformed Domain
  - Fourier Domain
  - Wavelet Domain
  - SVD Domain

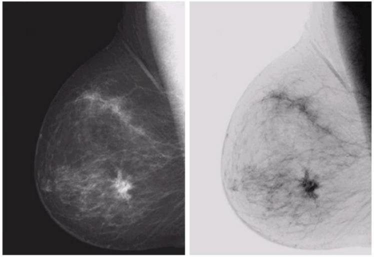




Point Processing

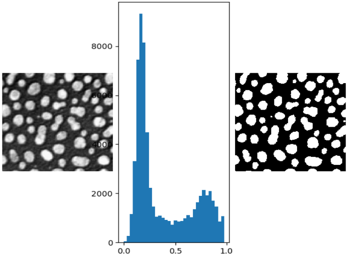
- Defn of Point Processing:
  - Let r be the pixel value in input image f
  - The output pixel value s=T(r)
  - T is called as point processing transformation
- Examples of point processing
  - s=Max-r, where Max is maximum allowed pixel value in the image
  - Let f(x,y) be input image
  - The output image g(x,y)=Max-f(x,y)

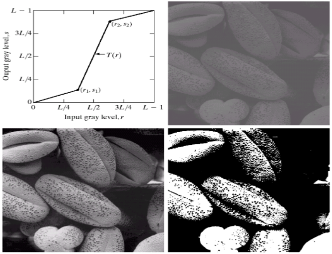




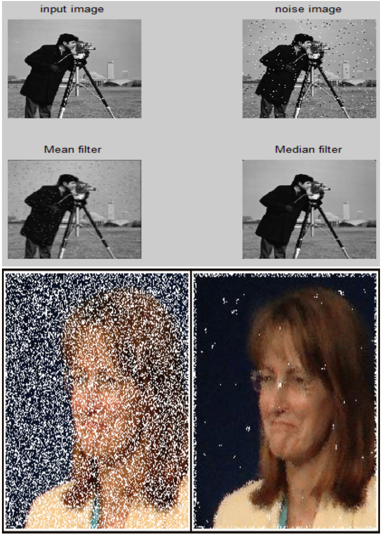
Point Processing (cont.)

- Image Thresholding:
  - s=0 if $r <= T_0$;
    s=1 otherwise
  - In Other words,
    g(x,y)=0 if
    $f(x,y) <= T_0$
    g(x,y)=1 otherwise
- Contrast Stretching



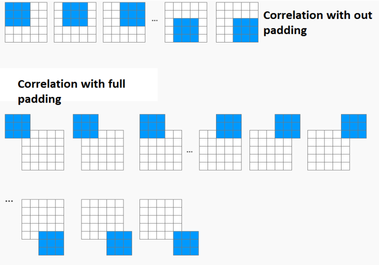


- **Definition of Neighbourhood Processing:** To transform the pixel value at a location, consult the pixel values of the neighbours also
- **Motivation:**
  - The neighbours of pixel at (x, y) will provide information about the pixel value at (x, y). This information can be used
- Examples of Neighbourhood Processing
  - Mean filter
  - Median Filter

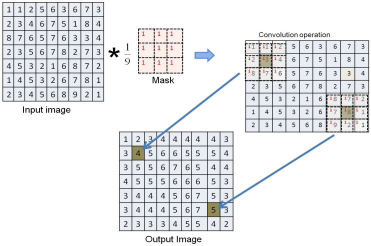


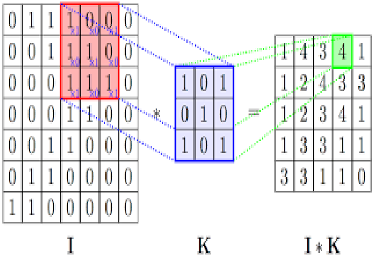
Neighbourhood Processing (cont.)

- Correlation
  - Correlation without padding(used in CNN)
  - Correlation with padding
    - Padding is done such a way that the size of the output is same as that of input
    - padding is done infinitely(Full Correlation)
  - Application: Template Matching using Normalized cross correlation

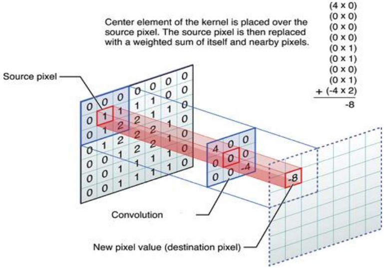


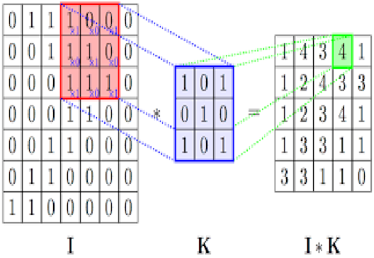
- Convolution:
  $\mathrm{Conv}(f,w) = \mathrm{cor}(f, w_{180})$
  - Full Convolution (Padding is done infinitely)
  - Partial Convolution
    - Padding is done such a way that the size of the output is same as that of input
    - No padding
  - Application: Polynomial Multiplication





Partial Convolution: padding such that size of input and output images are the same





Convolution Vs Correlation

- Cor(f, w) = conv(f, w_{180})

Questions

- Find the size of the cov(f, w), where size of f is $m \times n$ and the size of w is $a \times b$
  when
  - conv is full (infinite padding)
  - No padding
- Give an O(nlogn) algorithm to find product of to polynomials of degree n (Hint: use Conv)
- Find convolution and correlation 1) with full padding, 2) with partial padding, 3) without padding for the following inputs

3	0	1	2	7	4
1	5	8	9	3	1
2	7	2	5	1	3
0	1	3	1	7	8
4	2	1	6	2	8
2	4	5	2	3	9

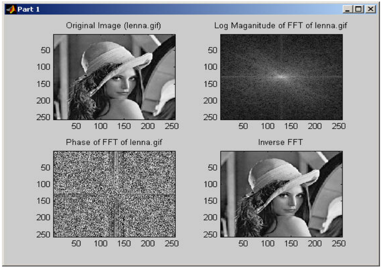
6 X 6 image

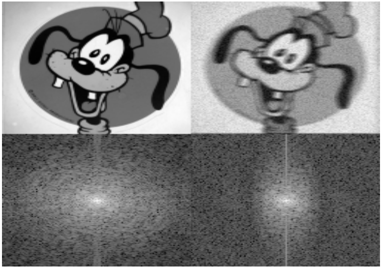
*

1	0	-1
1	0	-1
1	0	-1

3 X 3 filter

- Fourier Transform Domain Processing





Sum of Images

- **Defn of Image addition**
  Let $f(x, y)$ and $g(x, y)$, where $0 \leq x \leq m-1$ and $0 \leq y \leq n-1$ be two images with values with values within 0 to $L-1$.
  The addition is defined as
  - $(f+g)(x, y) = f(x, y) + g(x, y)$, where $0 \leq x \leq m-1$ and $0 \leq y \leq n-1$.
  - Transform $f+g$ to h with the range 0 to (L-1), also with the property that $(f+g)(x, y) \leq (f+g)(x', y') \implies h(x, y) \leq h(x', y')$
- Note that the min and max values of f and g are 0 and $L-1$ respectively, but the same is not true with $f+g$.
- It is required to transform the range to 0 to $L-1$.

Application:

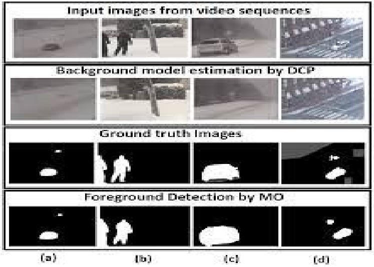
- CCD camera minimzes noise in the image captured using image averaging.
- It takes several images $f_i(x, y)$ $1 \leq i \leq k$, and finds $h(x, y) = \sum_{i=1}^{k} f_i(x, y)/k$.
- If $f_i(x, y) = f(x, y) + N_i(x, y)$, where $N_i(x, y)$ is the noise added to actual image f, then $h(x, y) = f(x, y) + \sum_{i=1}^{k} N_i(x, y)/k$.
- Since $N_i(x, y)$ will be positive and negative, $\sum_{i=1}^{k} N_i(x, y)$ will be a small value, and $\sum_{i=1}^{k} N_i(x, y)/k$ will be close to zero for large value of k.
- Hence $h(x, y)$ is a good approximation of $f(x, y)$.

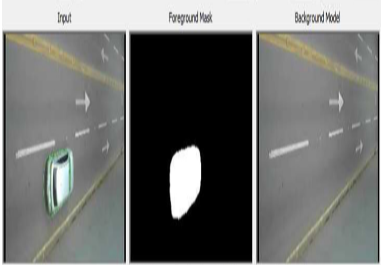
Image substraction

- **Defn:** The substraction is defined as $(f - g)(x, y) = f(x, y) - g(x, y)$, where $0 \leq x \leq m - 1$ and $0 \leq y \leq n - 1$, and transform the range of $f - g$ to integers from 0 to $L - 1$
- **Application:**
  - Angiogram is an example where image difference is used . In angiogram, hear is imaged using X-ray, say the image captured is $f_1(x, y)$, and another image is captured after injecting some contrast material into the blood stream.
  - The contrast material will be obsorbed more by the colostral content in the blood stream.
  - The X-ray image of the heart after injecting contrast material will show the presence of cholesterol content.
  - An another application of image subtraction is to detect moving objects.

Difference of Images (cont.)

- Moving objects in a video can be identified by taking difference of two consecutve frames.

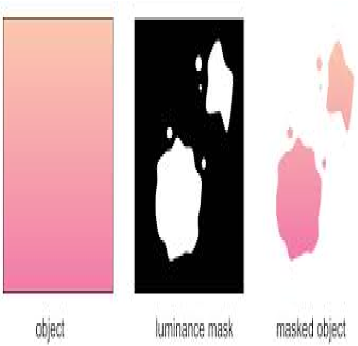




Multiplication of Images

Image multiplication

- **Defn:** The image multiplication is defined as
  $(fg)(x,y) = f(x,y)g(x,y)$,
  where $0 \leq x \leq m-1$ and $0 \leq y \leq n-1$,
  and transform the range of fg to integers from 0 to $L-1$
- **Application:**
  An application for image multiplication is found in Region of interest(ROI) detection. For instance, to extract image of a tooth from mouth image $f(x,y)$, define $g(x,y) = 1$ where (x,y) is possible locations of desired tooth; $g(x,y) = 0$ otherwise, and find $fg(x,y)$ which will give image of desired tooth image.



Common use of image multiplication is in masking also called as *region of interest* operations.

FIGURE 2.30 (a) Digital dental X-ray image. (b) ROI mask for isolating teeth with fillings (white corresponds to 1 and black corresponds to 0). (c) Product of (a) and (b).

Division of Images

- **Defn:** The image division is defined as
  $(f/g)(x,y) = f(x,y)/g(x,y)$, if $g(x,y) > 0$;
  $(f/g)(x,y) = f(x,y)/\epsilon$ otherwise,
  where $0 \le x \le m-1$ and $0 \le y \le n-1$, and transform the range of f/g to integers from 0 to $L-1$
- Note that a small quauntity ϵ is replacing 0 to make the division operation well defined. tem **Application:**
  - Usually the quality of image on screen projection by the LCD projector is degraded version of the actual image stored in computer.
  - The relationship between stored image $f(x,y)$ and the projected image $g(x,y)$ can be related as $g(x,y) = f(x,y)h(x,y)$, where $h(x,y)$ is the degrading function.
  - The original function $f(x,y)$ can be computed from $g(x,y)$ if we know $h(x,y)$ using image division $g/h(x,y)$.
  - It is possible to estimate $h(x,y)$ from the known $f(x,y)$ and $g(x,y)$ for the fixed LCD Projector.

Acknowledgements

- Images are downloaded from internet sources

Thank You! :)