CS 376A
Digital Image Processing

02 / 01 / 2023

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Today's Topics

- Questions/Comments?
- Quick review of what we've done
- Median Filtering for removing salt-and-pepper noise
- Continue Cross-Correlation of masks and images
  - Gaussian masks
  - relationship to convolution
  - Write code for cross correlation

Filters / Cross-correlation

- Reminder of Cross-correlation with a mask (aka filter)

Derivative and Smoothing masks

- What are the properties of
  - Derivative masks
  - Smoothing masks

Derivative and Smoothing masks

- Derivative masks
  - For edge detection
  - Values add up to 0
- Smoothing masks
  - values are positive and sum to 1

Enhancing Images

- Removal of salt-and-pepper noise from greyscale images is typically done with a median filter
  - consider a neighborhood around each pixel,
  - sort the grey values and choose the median value (the one that appears in the middle of the sorted list)
  - e.g. a 5x5 neighborhood will have 25 pixels, the median is the 13th highest value
  - example on the board w/ a 3x3 median filter

Enhancing Images

- Contrast the median filter with an averaging (aka smoothing) filter
- A smoothing filter computes a new value of a pixel by the following
  - given a mask of values, multiply each value in the mask by the corresponding pixel value in the image and add them up
  - then divide by the total of the values in the mask
  - if the total of the values in the mask is 1 (each value is some fraction --- the weight) --- no need to divide by the total
- A box filter is a simple smoothing filter which uses an equally weighted rectangular neighborhood.
- A gaussian filter is a smoothing filter that gives most weight to center pixel and gradually tapers off the weight the further from the center.

Considerations

- resulting value of output image pixels can be much larger than the input image pixels due to the summation, it is also possible for the output image pixels to yield negative values if the mask contains negatives --- so the type of the new image needs to be considered as possibly being different than the input image type
- what to do at borders of the image when cross-correlating or convolving and image and a mask and the mask overlaps (doesn't have corresponding pixels for one or more mask values.)
  - no processing -> make all the border pixels 0 in output image; copy the border pixels from input to output; make the output image smaller; reduce the size of the mask at the border locations; reflected indexing; circular indexing
    - note: this list comes from “Digital Image Processing” by Nick Efford.

Gaussian masks

- Program to generate gaussian masks
  - specify the width/height of the mask
  - specify the variance of the gaussian
  - let's examine some masks that have different variances
    - e.g. 7x7 mask w/ variance 0.5, 1, 1.5

Convolution

- Convolution
  - is similar to cross-correlation except the upper-left value in the mask is multiplied by the lower-right value in the image neighborhood and so on until the lower-right value in the mask is multiplied by the upper-left value in the image.
  - think of the mask being flipped along the horizontal axis and then again along the vertical axis AND THEN doing cross-correlation with the flipped mask
    - picture on the board
- If the mask is symmetrical both vertically and horizontally, then cross-correlation and convolution yield the same result.
- The two terms are often confused and sometimes used interchangeably (incorrectly.)

Computational considerations

- consider the computation involved in convolution or cross-correlation
  - if mask is size n x n, then for each pixel in the input image, we do n^2 multiplies and n^2-1 additions.
- if a mask is separable into two vectors that, when we take the outer product of them, we get the original mask then we can reduce the computational complexity by first convolving or correlating the image with the column vector and then the resulting image can be convolved or correlated with the row vector to get the output image (which would be the same as convolving or correlating the nxn mask with the original image).
  - how many multiplies and additions now?

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  - how many multiplies and additions now?
  - (2n multiplies and 2(n-1) additions) per pixel

Code for Cross-correlation

- Let's start writing some code to implement cross-correlation
  - let’s assume we’re doing blurring so the mask needs to be doubles
  - Once this code is done, your first assignment will be given
    - Will include implementing
      - median filter
      - Gaussian blurring
      - Sobel edge detection
      - Convolution method