Image analysis
lecture 2

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1 Image enhancment

Enhance part of an image in some way. Transform an image into a new image. Create a better. resore information, reduce noice. Enhance certain details, edges etc. Just look better. We dont increase the information. Can be performed in spatial domain. Point process : pixel base. Filter works with neighborhood Another way is in frequency domain. The chain of image analysis process. The first part today. Preprocessing enhancment. We must start by understanding the problem otherwise it hard to make decisions along the chain/pipeline

- image arithemic
- intensity transfer function
- histogram and histogram equalization

1.1 image arit´metics

we do aritmetics with images. Postion in matrix/image operator position in image.

- standar operation + - / *
- logic operator AND OR XOR

Pitfalls could be add and divide could be outside range of 0-255 for example. Need to normalize but needs to be done before we do the operation. otherwise we might have destroyed information. Bit depth important.

Useful way is to truncate the image.

We can subtract images. Leaf example and chessboard example. Binary or greyscale images.

Atitmetics usefull when parts of images should be excluded for example.

Logical operator in binary images, pixel example in slides. Nothing strange. But good method to add or remove certain objects in binary images.

1.2 noise reduction

using mean or median, useful in microscopy and night pictures/astrionomy

$$I = \frac{1}{N} \sum_{n=1...n} I_k \tag{1}$$

Reduction of noise by using the mean of the pixels by using images of the same scene. Good in microscopy and astronomy were the scene doesn't change.

1.3 application

- Image arithmetic useful in medication/diagnosis. Subtracting picture before contrast fluid with the picture after to get en enhancement/ better picture of the blood vessels.
- change or motion in a scene. Persons in scene before and after example.
- illumination correction by subtraction background image. Max or median of the pixel intensities.

2 intensity transfer function

$$g(x, y) = Tf(x, y) \tag{2}$$

- linear (neutral negative, contrast, brightness)
- smooth, gamma log
- arbitrary

old value on x axis new on y axis.

2.1 The negative transformation

the inverse

$$g(x, y) = max - f(x, y) \tag{3}$$

$$\begin{bmatrix} 255 & 254 & 253 \\ 125 & 130 & 110 \\ 4 & 3 & 0 \end{bmatrix} \Rightarrow \begin{bmatrix} 0 & 1 & 2 \\ 130 & 125 & 145 \\ 251 & 252 & 255 \end{bmatrix} \tag{4}$$

useful in medical image processing. Retina example. Easier to distinguish brighter lines/object. Sometimes the opposite.

2.2 Brightness

If we add a constant to the image it becomes brighter. Subtracting will make it darker. C positive integer or

$$g(x, y) = f(x, y) + C \tag{5}$$

2.3 Contrast

By multiplying the image we spread out the information and increases the contrast

$$g(x, y) = f(x, y) \times C, C > 1 \tag{6}$$

if C $<$ 1 reduce the contrast.

2.4 Gamma transformation

$$g(x, y) = C \times f(x, y)^{\gamma} \tag{7}$$

Computer monitors $\gamma \approx 2.2$

- Computer monitors $\gamma \approx 2.2$
- eyes ≈ 0.45
- microscopes ≈ 1

microscopes should have 1. 1 to 1 ratio. Lower gamma brighter image. Gamma high, darker.

2.5 Log transformation

Used to visualize dark regions of an image. To display the Fourier spectrum. Enhance the brighter regions.

$$g(x, y) = Clog(1 + f(x, y)) \tag{8}$$

2.6 arbitrary

only one output per input. Possibly not continuous.

3 Intensity histogram and histogram equalization

Gray scale histogram show how many pixels at each intensity level.

Normalized histogram: normalized by the total number of pixels in the image. Histogram show intensity distribution. How many pixels of certain intensity.

Intensity histogram doesn't say anything about the spatial distribution of pixel intensities. Images with the same pixels histogram can be totally different.

What do we use them for?

- Thresholding, intensity threshold. Decide intensity all above or under is background. Works with bi-modal histogram
- analyze the brightness and contrast
- histogram equalization

Analyze the brightness. See the transformation "chopping" the histogram. Could see that information might be missing. Low contrast = compressed histogram. When increasing we stretch the histogram. Transfer function slope.

3.1 histogram equalization

create an histogram with evenly distribution grey levels. for visual contrast enhancement. The goal is to flatten the histogram, produce the most even histogram.

3.2 Cumulative histogram

sum the number of pixels along the x axis intensity. Steep slope. Intensely populated parts of the histogram. Flat slope: sparsely populated parts of the histogram. Strive to a even slope.

3.3 example CDF

Multiplying the CDF value with number of gray levels -1 gives the intensity transfer function. We can the map the new gray level values into the number of pixels. it possible that two bins will be mapped to the same new position.

look at this again

3.4 local histogram equalization

useful when only parts of image need to be enhanced

3.5 Conclusion

- useful when histogram narrow
- drawback, amplifies noise, can produce unrealistic transformation
- information can be lost. no new information gained.
- Not invertible, usually destructive.

Usefulness depends on the amount of different intensities.

3.6 Histogram matching

Want to mimic histogram of another image. Compute the histograms and CDF for each image. For each gray level $G_1 \begin{bmatrix} 0 & 255 \end{bmatrix}$ find graylevel G_2 so $F_1(G_1) = F_2(G_2)$ The matching function: $M(G_1) = G_2$

Not always the best solution either.

4 Summary

- Many common tasks can be described by image arithmetic
- histogram eq useful for visualization
- watch out for information leaks

to think about

- relation between arithmetic and linear transfer function

- what can we know of an image from the histogram
- 8-bit image A, how will it look like B = 255*(A+1)
- conclusion if first last column really high?
- better resolution combining multiple images of same sample?