CS 3430: S24: Lecture 12

Edge Detection as Derivative of Luminosity

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Differentiation-Based Ideas in Other Areas

In this part of Lecture 12, we will talk how differentiation-based techniques are used in other areas of science, engineering, and technology.

One such area is image processing and, in particular, edge detection which is based on estimating the changes in luminosity at each pixel. If the change is great (i.e., its value is above some threshold) at a given pixel, then that pixel can be part of an edge.

An edge is, abstractly speaking, a sequence of image pixels where every pixel has a large change in luminosity; of course, more information is needed to determine if a pixel is part of an edge, some topological/geometric information may be necessary; regardless of the overall edge detection technique, changes in luminosity must be estimated.

Luminosity

Images are 2D matrices of pixels; each pixel is typically a 3-tuple (R,G,B) where 0 <= R, G, B <= 255, and R abbreviates “red,” G – “green,” and B – “blue.”

Luminosity can be viewed as a function that converts the red, green, and blue values of a pixel to one grayscale value between 0 and 255.

There is a lot of psycho-vision research on color perception that various luminosity functions utilize. One such function is

luminosity(r,g,b) = 0.2126R + 0.7152G + 0.0722B.

There are also non-linear luminosity functions.

Gradients

We can use gradients to estimate changes in luminosity.

Gradients indicate changes in image intensity.

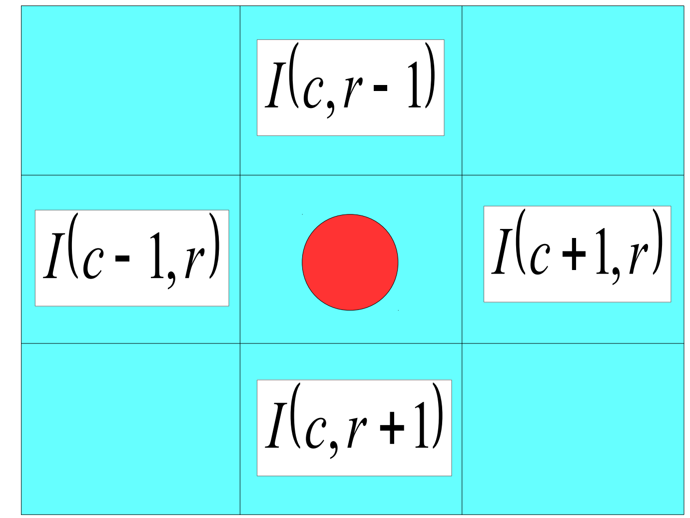
Gradients, if viewed as vectors, have directions and magnitudes.

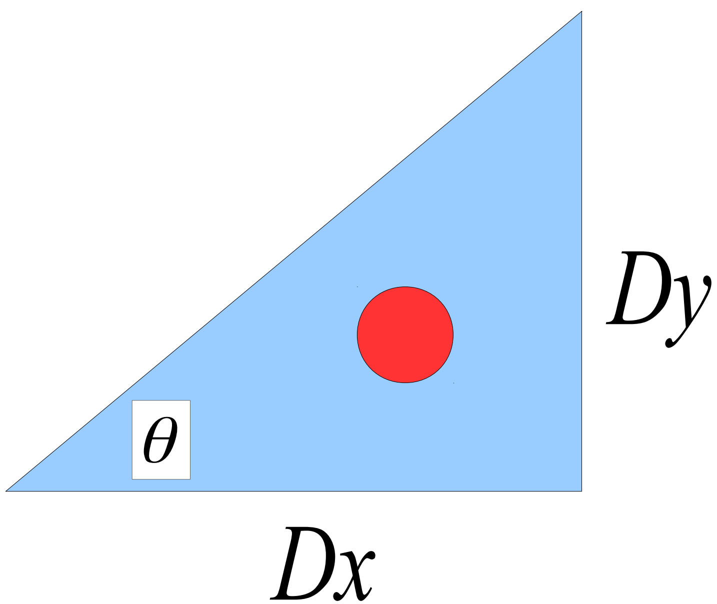
Gradients can be computed for each pixel or for specific image regions.

Vertical & Horizontal Changes: *Dy* & *Dx*

$$Dy = I(c, r-1) - I(c, r+1)$$

$$Dx = I(c+1, r) - I(c-1, r)$$





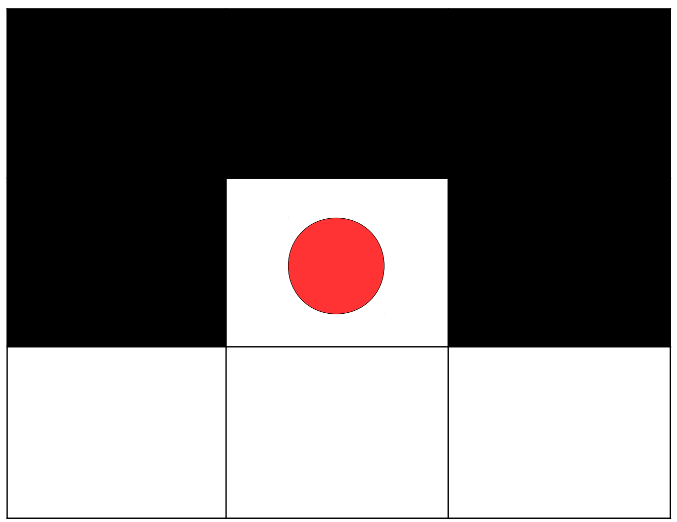
$\|G\| = \sqrt{Dy^2 + Dx^2}$ is the gradient's magnitude at $I(c, r)$

$\theta = \tan^{-1}\left(\dfrac{Dy}{Dx}\right)$ is the gradient's orientation

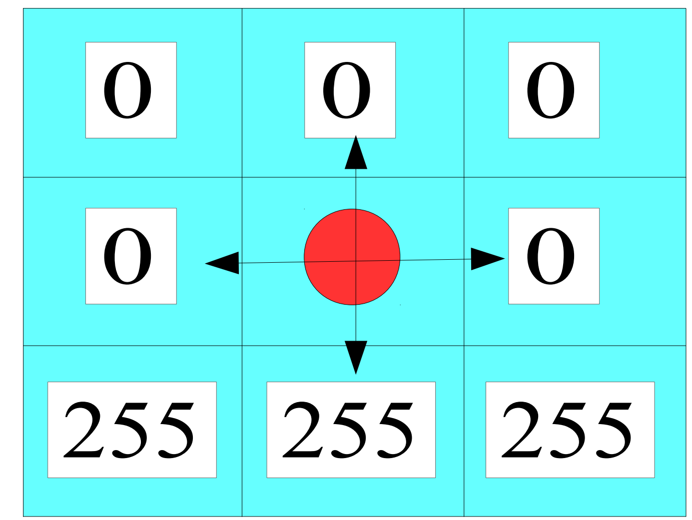
What if $Dx = 0$? In this case, we can set Dx to some small default value, e.g., 1.

Example

Image



Pixel Values



$$dy = 0 - 255 = -255; dx = 0 - 0 \approx 1$$

$$\| G \| = \sqrt{(-255)^2 + 1^2} = 255.00196078 \approx 255$$

$$\theta = \left(\tan^{-1}\left(\frac{-255}{1} \right) \right) \frac{180}{\pi} = -89.775311^\circ \approx -90^\circ$$

Edge Pixel Detection Algorithm

Grayscale RGB pixels with luminosity to convert each RGB pixel to grayscale pixel.

Compute ***Dy*** and ***Dx*** at each grayscaled pixel.

Compute gradient's magnitude and orientation with ***Dy*** and ***Dx***.

Threshold the gradient’s magnitude and/or orientation to set the pixel value to 0 if it’s not an edge pixel and to 255 if it’s an edge pixel.

Edge Pixel Detection Algorithm