Digital Image Processing Labs

EDGE DETECTION

Sharp changes in pixel intensity could signify the presence of an object or the edge of an object. For instance two consecutive pixels where one that is close to black with a color intensity of 0 and one that is close to white with a color intensity of 235.

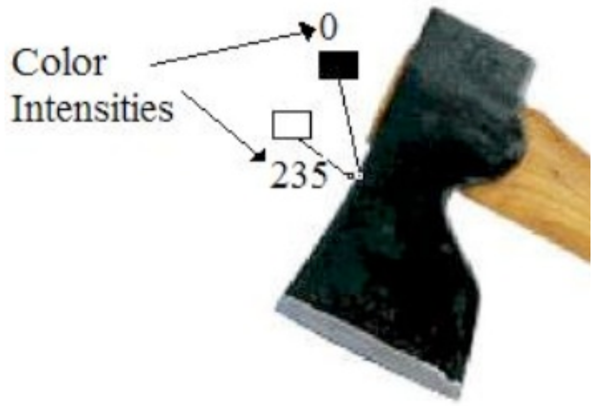

Figure 1: The color intensities of two adjacent pixels at the edge of an object.

The goal of edge detection is to highlight the edges of an object in an image. This is accomplished by accentuating sharp changes in color intensity like the one shown in figure 7. Edge detection of an image significantly reduces the amount of data and filters out information that may be regarded less relevant.

Edge detection can be accomplished in a variety of ways. The simplest way is to compare the difference in adjacent pixel values to a certain color intensity or threshold. We start at the upper left corner of an image and compute the difference in color intensities between every adjacent pixel. The difference is then compared to a certain threshold and if the difference is greater than the threshold we can conclude that an edge has been detected.

Activity 1: Detecting Sharp Changes in Intensities (by hand)

Edge detection can be accomplished in a variety of ways. The simplest way is to compare the difference in adjacent pixel values to a certain color intensity or threshold. We start at the upper left corner of an image and compute the difference in color intensities between every adjacent pixel. The difference is then compared to a certain threshold and if the difference is greater than the threshold we can conclude that an edge has been detected.

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For this activity, set the threshold to 20, meaning that if the difference between the intensity in two adjacent pixels is greater than 20, there is probably an edge between those pixels. If the difference is less than 20, it is not likely that there is an edge between those pixels.

1. On the matrix below, calculate the difference between the intensity values for the first two boxes in the top row (starting with the leftmost boxes in the two leftmost boxes in the top row). If the difference between the boxes is greater than or equal to the threshold (again, in this activity, the threshold is 20), color the second of the two boxes black with a pencil. If the difference is less than the threshold, leave the box white.
   ***Note*:** Use the absolute value when calculating the difference.
   As an example, if we consider the leftmost two boxes in the top row, the difference between the two is 10. This value is less than the threshold so we leave the second box white.
2. Compute the difference in values between the second and third boxes in the top row. If the difference between these boxes exceeds the threshold color the second of the two boxes black.
3. Continue to calculate the differences, compare with the threshold value, and shade the second of the two boxes (if needed). Repeat the above steps until you reach the end of the row. Then move on to the next row and repeat until you complete the entire matrix.

45	55	105	98	95
102	21	18	40	45
95	100	110	155	162
15	105	140	110	125

Hint: There are a total of **6** boxes that need to be colored.

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Activity 2: Edge Detection Applets

1. To begin this activity, you will need to download the digital image, which can be found at http://dk12.ece.drexel.edu/MT/boy.jpg
2. Open the "Edge Detection" applet at http://dk12.ece.drexel.edu/image_guis/EdgeDetect.html or following the link on the main Image Processing Labs page. The applet is designed perform the same calculations that you did in Activity 1 for every pair of pixels in a digital image.
3. Click "Select File" and upload the image of the boy from Step #1.
4. Experiment with various "threshold" levels. **Please leave Average set to Zero.**
    - What did the resulting image look like with a high threshold value (say, 150)? Explain, using your understanding of the process from activity 1, why the resulting image looked as it did.
    - What did the resulting image look like with a very low threshold value (say, 5)? Explain, using your understanding of the process from activity 1, why the resulting image looked as it did.
    - What are the characteristics of the resulting image for an "ideal" edge detection? Find an "ideal" threshold value.

Activity 3: Improving Edge Detection using Average Values

We can improve our edge detector by altering our algorithm (procedure). One way of enhancing our detector is to compare the average values of adjacent pixels instead of each individual pixel value.

> *Think about it…* What is the difference between taking the difference between two adjacent cells and taking the difference of the averages? Why might this approach "improve" the edge detection?

We begin by taking the average values of the first set of two pixels (first and second pixel) and the second set of two pixels (third and fourth pixel). Then we compute the difference between these two average values and compare it to a threshold like we have done in our previous algorithm. If the difference is greater than the threshold the third pixel is colored black. Otherwise the third pixel is colored white. We repeat this procedure by moving one pixel to the right (comparing the averages value of pixels two and three with the average value of pixels four and five). The procedure is repeated across each row and then again for each row until the last pixel has been reached.

Again, in this activity, set the threshold to 20, meaning that if the difference between the averages is greater than 20, there is probably an edge. If the difference is less than 20, it is not likely that there is an edge.

1. On the matrix below, calculate the average value of the first two boxes and compare it to the average value of the next two boxes. If the difference between the average values

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exceeds the threshold color the third box black. If not, leave the box white.
***Note*:** Use the absolute value when calculating the difference.
As an example, the average of the first two boxes is 50 [(45+55)/2]. The average of the third and fourth boxes is 98.5 [(105+95)/2]. The difference between those two averages is 48.5; since 48.5 is greater than 20, we shade the third box black. If not leave it white.

2. Repeat the process across the first row. *Now move on to the next two pairs of pixels (the first pair is the second and third boxes and the second pair is the fourth and fifth boxes). If difference between those two averages is is greater than 20, shade the box pixel black.*
3. Repeat for each row in the matrix.

45	55	105	95	45
102	22	18	40	46
95	125	155	165	85

Hint: There are a total of **4** boxes that need to be colored.

Activity 4: Edge Detection Applets (with Averages)

1. Again, in this activity, you will need the image from Activity 2, which can be found at http://dk12.ece.drexel.edu/MT/boy.jpg
2. Open the “Edge Detection” applet at http://dk12.ece.drexel.edu/image_guis/EdgeDetect.html or following the link on the main Image Processing Labs page. The applet is designed perform the same calculations that you did in Activity 3 for “blocks” of pixels in a digital image. This is accomplished through adjusting the “Average” slider, which varies the block size. If you set the Average Slider to 2, the applet will take the average value of every two pixels and compare it to the average value of the next two pixels. If set the Average Slider to 3 the average value of every three pixels will be compared to the average value of the next three pixels and so on.
3. Click “Select File” and upload the image of the boy from Step #1.
4. Experiment with the algorithm on your image. Try various threshold values such as 10 and 150. Try a different number of block sizes such as 3 and 5.

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Questions for Reflection

1. How did the edge-detected image compare to the one in activity 5 at low threshold?
2. Is this “average value” procedure "better" than the one used in activity 1 & 2? Why?
3. What would happen if you entered a block size of 1 in this activity? Why?
4. Can you think of any examples of edge detection? (To get started, think about the local news…)

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