Computer Vision
Exercise Sheet 9

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Exercise 1: Convolution (6 Points)

a) What is a convolution? What operations can be represented in this format? (2 points)

b) What is a kernel? Make an example of a squared one. (1 points)

c) Can you think of operations that cannot be represented as a convolution? Why? (3 points)

Exercise 2: Edge Detection (14 Points)

a) Explain, considering the given code sample, each step of the Sobel-Algorithm. What is it used for? What are the two mathematical concepts behind this algorithm? Individuate their implementation in the code.

```
function sobel(Image image) {
   int[][] Sx = { {-1,0,1},  {-2,0,2}, {-1,0,1} };
   int[][] Sy = { {-1,-2,-1}, {0,0,0}, {1,2,1} };
   for (int x=1;x<image.getWidth()-1;x++)  {
      for (int y=1;y<image.getHeight()-1;y++)  {
         int intensity_sum_x=0, intensity_sum_y=0;
         for (int i=-1;i<=1;i++) {
            for (int j=-1;j<=1;j++) {
               int intensity = image.getintensity(x+i, y+j);
               intensity_sum_x+=(intensity*Sx[1-j][1-i]);
               intensity_sum_y+=(intensity*Sy[1-j][1-i]);
            }
         }
         int new_intensity = sqrt((intensity_sum_x)*(intensity_sum_x)
                                 +(intensity_sum_y)*(intensity_sum_y));
         edges_image.setIntensityPixel(x, y, new_intensity);
      }
   }
   return edges_image;
}
```

(6 points)

b) Compute the LoG matrix given the (1) Laplacian

$$L = \begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

and (2) the Gaussian

$$G = \begin{bmatrix} 0.0625 & 0.125 & 0.0625 \\ 0.125 & 0.25 & 0.125 \\ 0.0625 & 0.125 & 0.0625 \end{bmatrix}$$

and (3) the discrete convolution defined as follows:

$$y(m,n) = x(m,n) \otimes h(m,n) = \sum_{i=-1}^{1} \sum_{j=-1}^{1} x(i,j)h(m-i,n-j); \quad (1)$$

Keep the axis as follows: m and i increasing moving to the right and n and j increasing moving downward in the image.
(8 points)

Exercise 3: Harris Corners and SIFT (10 Points)

a) What is a point of interest in an image? How is it defined? Which image properties can be used to find such points? (3 points)

b) Explain the Harris-Corner pseudo code (4 points)

c) What are the differences between Harris Corners and SIFT features? (3 points)