Lab 08
Image Processing II

A. Filters and Convolution (25 points, 5 points for each question)

Generate the following filters and observe the effect on an image. Describe in the report how these filters effect an image or if the filters are extracting any kind of features. (We mentioned some of them in the class)

-1	-1	-1
2	2	2
-1	-1	-1

(a)

-1	-1	2
-1	2	-1
2	-1	-1

(b)

-1	-1	-1
-1	8	-1
-1	-1	-1

(c)

-1	0	1
-2	0	2
-1	0	1

(d)

0	-1	0
1	0	1
0	-1	0

(e)

B. Denoising a Picture (15 points)

Write a program to denoise the image "Saturn.jpg". The program should reduce the noise level of the image by using different filters. Describe your experiment and include the result images in your report. The filters that you may want to try includes 1) mean filter, 2) gaussian filter, 3) total variation filter, 4) bilateral filter and 5) wavelet denoising filter. Apply the filter to the image for several times and examine if this helps improving the image quality. You may consider to sharpen the image by applying the Laplacian filter to the denoised image.

C. Properties of Convolution (20 points)

1. Try to verify the following properties of convolution:
   - (a) Commutative $f(x) * g(x) = g(x) * f(x)$
   - (b) Associative $f(x) * [g(x) * h(x)] = [f(x) * g(x)] * h(x)$
   - (c) Distributive $f(x) * [g(x) + h(x)] = [f(x) * g(x)] + [f(x) * h(x)]$

These properties become important if you think of every operation as a filtering of an image, then you can use a combination of different filters to obtain a particular effect. One example of this would be a sharpening filter that is implemented with an identical filter and a smoothing filter. Remember as well that the convolution is a linear operator, so the combination of convolutional filters is linear as well.

2. Can you think of a non-linear filter? Would it need a special filter or a special operation?

D. Image Segmentation and Color Space (20 points)

Calculate the area size of the yellow fan in image "YellowFan.png". Demonstrate the yellow fan area in a black and white image, where black pixels represent background and white pixels represent the fan area. Describe your image processing procedure and approach. How good do you think your results are?
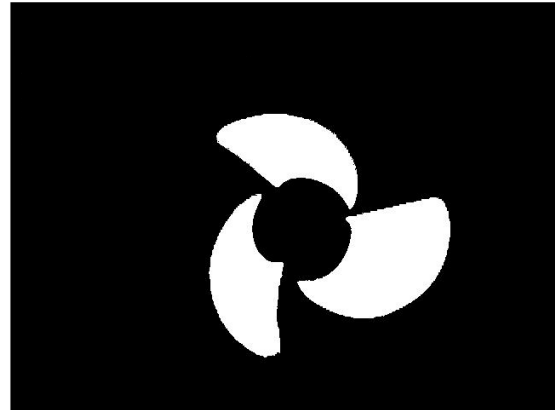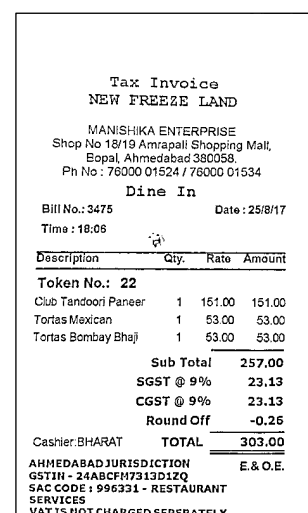

E. Document Scanner (20 points)

Nowadays, plenty of document scanner apps let users capture a photo of a document with their phone and convert it into a clean, rectangular PDF. In this question, you will write a program to scan *invoice.jpg*. The scanned invoice should be neatly rectified and cropped. The background of the invoice should be mostly a uniform white, with even illumination, and the foreground text should be crisp and visible with high contrast.
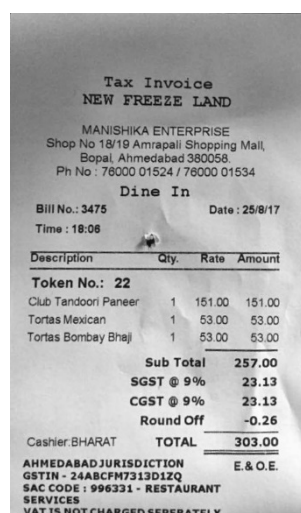
Original image   Intermediate image   Scanned invoice