Lab 3 – Image processing

Idea
In this lab you are going to use the camera together with MATLAB’s imaging toolbox to create a change counter. You will take a picture with the camera and then use MATLAB to process the image to find and count the change.

Objectives
- Image processing techniques
- More MATLAB

Procedure
The concept is fairly easy; when taking a picture of some coins, the picture can be converted to a black and white image. The black represents the background and the white is the coins. The coins in the image can then be labeled and the area of each coin can be calculated. With normalizing the areas of all the coins and then using simple ratios between the different areas, we can distinguish between quarters, dimes, nickels and pennies. In this lab you will go through these steps to build your change counter.

Taking the picture of the coins
1) Take a couple of pictures of some change arranged on a table.

   To prevent unnecessary difficulties with all the different exceptions with building a change counter we are going to specify a couple of guidelines for taking the pictures:
   - Each picture may only contain quarters, dimes, nickels and pennies.
   - Each picture must contain at least one quarter.
   - The coins may not overlap or touch each other.
   - Lay the coins on a surface that would provide a good contrast with the coins.
   - Make sure you have good lighting when taking the picture.

Finding the coins with MATLAB
The hardest part of this project is to accurately change a color picture of the coins, Figure 1, into a black and white picture where the coins are white and the rest is black, Figure 2. (Recall that in an image, black is represented with zeros and white with ones. The assumption is made that background data defaults to zeros while ones represent objects in the foreground)

![Figure 1](image1.png) ![Figure 2](image2.png)
Note, when first taking the picture and converting it to black and white, you will see that the coins are actually black and the rest is white. This is simply due to the fact that the coins are darker than the white background.

Some of the problems that you will encounter are:

- When taking a picture, due to reflection, some sections on coins will appear just as light as the background. When converting to a black and white image, the coins will not be solid objects. Figure 3. This could cause inaccurate area calculations of the coins.
- Due to inadequate lighting while taking a picture, the corners of your image might appear darker than the coins. In the black and white image, these corners will also show up as foreground objects and might be interpreted as coins. Figure 4.

1) Figure 2 shows a picture that has been properly converted to a black and white image. This was done by using a combination of MATLAB functions like: RGB2Gray, im2bw, imfilter, and imfill. Write some MATLAB code that would convert a color image of coins to a black and white image as described above.

**Labeling coins and finding areas**

In order to distinguish between the different foreground objects in the picture, each object (coin) needs to be labeled. bwlabel does this. After the coins are labeled you need to figure out how to single out a coin in order to calculate its area. bwarea is a function that returns the area of all the objects in the foreground.

2) Using bwlabel, bwarea or any other MATLAB functions, write some code that will process a black and white image and return to a variable an array of areas. The array will be the same size as the number of coins in the picture. Each element in the array will contain the area of its corresponding coin.

**Ratios between coins**

When taking a picture of coins, the size of the coins in the picture depends on the distance the camera is from the coins when taking the picture. Thus the only thing that remains constant in all the different pictures is the coin size ratios.

3) Use this fact and the array of areas to determine what coins are present in the image. Write some code that will then calculate the value of the change in the picture.
Post Lab

Write a paragraph summarizing what you have learned in this Lab concerning image processing. Also include a copy of all MATLAB code written and a copy of all the plots and images created. Turn in your lab results to your Lab TA at the beginning of the next Lab session.