LAB # 12: Texture Based Descriptor

Objective:

The objective of this lab is to develop an understanding of texture-based descriptors and how they can be further used.

Theory:

Statistical features can help describe the image through its histogram. Features like skewness, entropy and uniformity etc. can be extracted from the histogram and can be used to describe the image and distinguish one image from another.

Texture Based Descriptors can be useful for gleaning such information from an image that can provide good features for the said image. **Grey Level Co-occurrence Matrix** contains the information of two gray levels occurring together in an image based on a predefined rule. The changes in the rule can change the GLCM. The following parameters of GLCM can be used for texture description:

Maximum probability

$$\max_{i,j}(c_{ij})$$

Contrast

$$\sum_i \sum_j (i-j)^2 c_{ij}$$

Uniformity

$$\sum_i \sum_j c_{ij}^2$$

Entropy

$$-\sum_i \sum_j c_{ij} \log_2 c_{ij}$$

Frequency Spectral analysis can be performed to extract features/textures from the images. It offers the following benefits and exhibits the following properties:

- Suitable to detect directionality of periodic and almost periodic 2-D patterns in an image
- Periodic texture patterns are easily detectable by concentration of high energy burst in the spectrum
- Features of Fourier spectrum for texture representation are:
  - Prominent peaks in the spectrum give the principal direction of texture patterns

- The location of peaks gives the frequency and thus the scale of repetition of a pattern

- Eliminating any periodic components via filtering leaves non-periodic image elements which can be described by statistical techniques

- Simplified by expressing the spectrum in polar coordinates to yield a function $S(r, q)$ where S is the spectrum function and r and q are the polar coordinates.
  For each direction q , $S(r, q)$ = a 1-D function $S_q (r)$
  For each frequency r , $S(r, q)$ = a 1-D function $S_r (q)$
- Analyzing $S_q (r)$ for a fixed q , gives the distance from the origin and thus the scale of repetition of a texture pattern.
- Analyzing $S_r (q)$ for a fixed r, gives direction and thus the orientation of the periodic texture pattern.
- To measure this analysis, we define two quantities

$$S(r) = \sum_{\theta=0}^{\pi} S_\theta(r)$$

$$S(\theta) = \sum_{r=1}^{R_0} S_r(\theta)$$

These quantities measure the spectral response and give the dominant directions and scales of periodic texture patterns.

Some Useful Commands:

The python package that will be needed for the following function is **scikit-image.** You may need to download the .whl file and install it manually if pip doesn't work.

1. To find the GLCM of an image: **my_GLCM = skimage.feature.greycomatrix(my_image, [distances_at_which_the_covariance_is_to_be_checked], [angles_at_which_the_covariance_is_to_be_checked], levels=None, symmetric=False, normed=False)**

The output of the above function will be a 4D array. The value my_GLCM [i,j,d,theta] is the number of times that grey-level j occurs at a distance d and at an angle theta from grey-level i. If normed is False, the output is of type uint32, otherwise it is float64. The dimensions are: levels x levels x number of distances x number of angles.

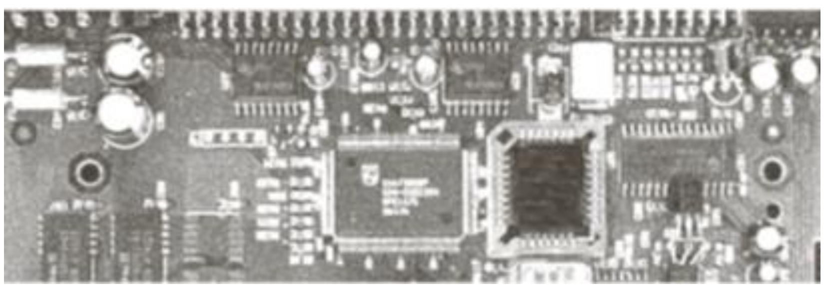
2. To calculate different properties of a GLCM matrix:
   my_property = skimage.feature.greycoprops(my_GLCM, prop='my_property')

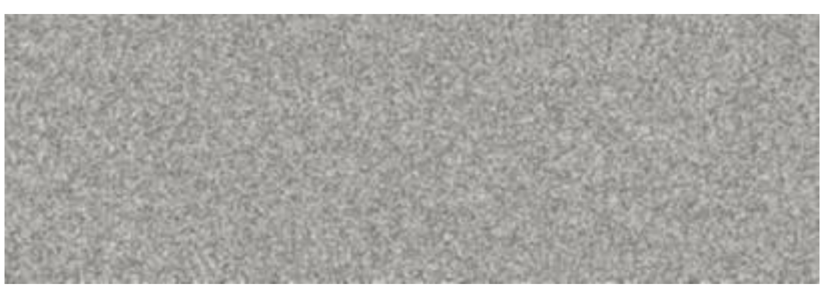
The prop flag can be set to 'contrast', 'dissimilarity', 'homogeneity', 'energy', 'correlation' or 'ASM'. Uniformity is also called energy

Lab Tasks:

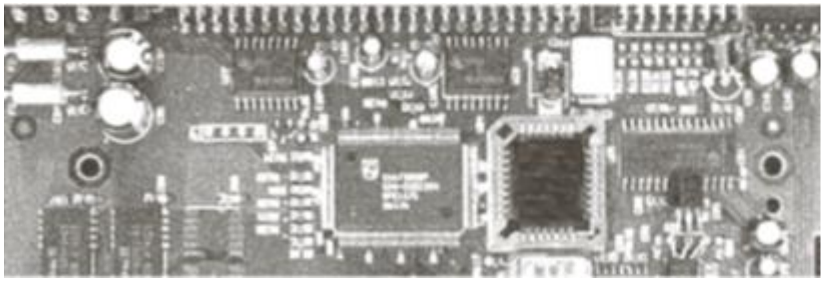
Lab Task 1: Compute the histograms of the following images and then compute the following statistical features from the histograms:

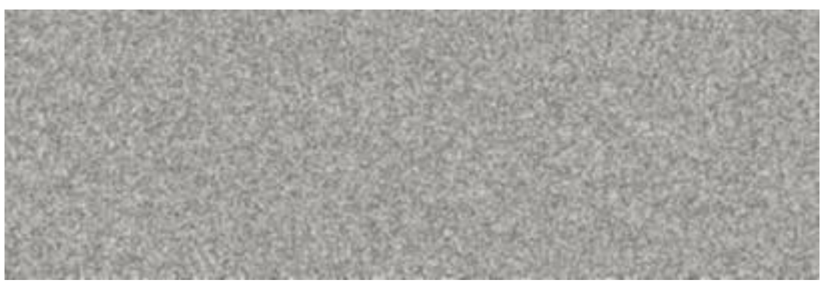
- Skewness
- Uniformity
- Average Entropy





Lab Task 2: Calculate the Grey Level Co-occurrence Matrix (GLCM) for following images. Display those GLCMs as images. Then calculate the parameters of GLCM mentioned above for all the images and compare the results. Calculate the uniformity and entropy from GLCM with using the built-in functions.





Lab Task 3: Use spectral analysis to extract feature profile S(r) and S(theta) for given images and plot these feature profiles for different r and theta values.