

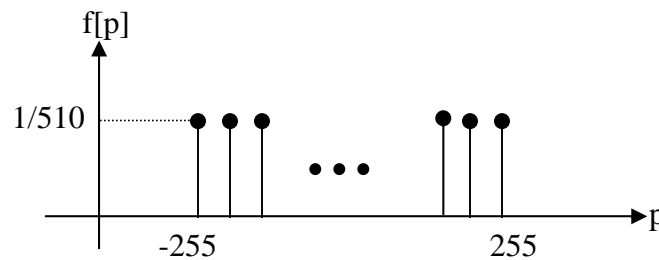


Homework Assignment 1 - Due Jan 25, 2007

Your answers must be justified by showing all work. For homework problems requiring work in Matlab, you must submit your copy of the commented matlab code as well as an original (no photocopies) of any figures, images, etc. For homework problems requiring written explanations and/or discussions, all answers must be in your own words. That is, DO NOT copy from the text book, lecture notes, websites, etc. Answers to all homework problems (except Matlab code and figures generated in Matlab) must be handwritten.

1. List and describe the different types of resolution that one must consider when processing digital images.
2. Generate two 256x256 8-bit images for demonstrating simultaneous contrast, where the inner small squares have gray level values of 127 and the backgrounds have gray level values of 50 and 210. Display the images to verify the effects of simultaneous contrast (`imshow`). Next, compute the contrast of the object (the inner square) with respect to its surround. Compute the normalized contrast of the image. Now add Gaussian noise to the images (`imnoise`, with default levels of mean and variance for the noise) and recomputed their contrast. Did the contrast values change, and if so how?
3. Download the image “pout” from the course website, and load the image into Matlab. Load the image into Matlab using `imread`. In Matlab, write your own function to compute an image’s normalized contrast, and name the function `imagecontrast`. Use `imagecontrast` to compute the contrast of the image. Apply histogram equalization to the image (`histeq`). Display the original and the modified image to view the effects of histogram equalization. Compute the new normalized contrast of the image. Explain how histogram equalization improved the contrast.
4. An image is represented by the following mathematical expression:
$$g(x, y) = \sin(20\pi x)\sin(20\pi y) + \sin(40\pi x) + \sin(60\pi y)$$
, where x and y have units of millimeters.
 - a) Sketch $G(f_x, f_y)$.
 - b) What are the minimum sampling frequencies (Nyquist frequencies) that can be used for this image so as to avoid any folding of the sinusoidal components?
 - c) Assume the image is sampled at a rate of 40 samples/millimeter in the x and the y -directions. Sketch $G(f_x, f_y)$ for the sampled image.
 - d) Assume the image is oversampled, where the sampling frequency is 100 samples/millimeter. Sketch $G(f_x, f_y)$ for the sampled image.

5. We have two 512x512 8-bit gray level images. One is an original image, and the other is a copy that has been compressed using a lossy JPEG compression scheme. Assume the difference between the original image and the compressed version is random. The pixels' intensity values are equally likely to be any one of the 256 levels of gray, indicating that its probability density function is uniform:



Calculate the image's mean square error. Note: for the purposes of this HW problem, you may assume the random variable, p , is continuous or discrete.

6. In Matlab, add salt and pepper noise to the image “pout” (`imnoise`). Use a 3x3 median filter to remove the noise (`medfilt2`, `conv2`). Write your own function to compute the average least squares error between two images, and name the function `mse`. Use the new function to compute the error between the original and the noisy image. Compute the error between the original and the denoised image. Explain your results.
7. As a rule of thumb, the peak-to-peak value of images can be estimated as $n\sigma$, where n varies between 4 and 6 and σ represents root-mean-square error. Letting $n = 5$, show that

$$SNR_{peak} = SNR + 14dB.$$

Write your own Matlab function to compute the signal-to-noise ratio of an image, and name the function `snr2`. Use the new function to compute the snr of the denoised “pout” image obtained in part 4. Write your own Matlab function to compute the peak signal-to-noise ratio of an image, and name the function `snrpeak2`. Use the new function to compute the peak-snr of the denoised “pout” image. Compare the results to the results that are predicted by the above equation.

8. Discuss the advantages and disadvantages of using subjective versus objective image quality metrics, as well as describe three methods that could be used in each approach.
9. Explain how linear system theory can be used to model the human visual effect known as the “Mach Band Effect”.