Purpose: Become more proficient with spatial domain image enhancement techniques as presented in Chapter 3 of the textbook, and how they can be combined.

Procedure: For *each* MATLAB m-file you write, be sure to comment the code sufficiently, and include initial comments as a crude help system. No Image Processing Toolbox (or *any other* Toolbox) programs should be used.

For all images below, the origin should appear in the upper left corner, and the image axes should be such that the x and y dimensions of an individual pixel should appear to be square. The x-axis is for the rows and the y-axis is for the columns. Unless otherwise specified, assume the images utilize an 8-bit gray level range. The gray levels should map 255 to white and 0 to black for display.

- The primary requirements for this Project are to recreate, using your own original code, each of the image enhancement steps depicted in Figure 3.63(b)–(h) of your textbook.[1] Note that you'll also use two test images given to you *before* you proceed to processing Figure 3.63(a).
- Once your generalized image mask/filtering program has been verified on the test images (see below), you will load the "mat" file `bones.mat` from the "Images" directory of the "Files" area on the course website. This mat file contains Figure 3.63(a), the image with which you start.
- Use the generalized image mask/filtering program you've been working on in previous weeks to implement the various enhancement steps.
  - Your image mask/filtering program must accept at least two inputs: an image array from the workspace (that represents a gray scale image), and a mask array from the workspace. The latter argument may be a scalar, or an odd sized square array (e.g., 3×3, 5×5, 7×7, 9×9, $11 \times 11 \ldots$).
  - Your program must pad all the edges of the original image to allow the mask to process every pixel in the original image. The default type of padding operation for your program may be replication padding, mirror padding, or zero padding—your choice. *Optional:* You may include a third input to your program to control the type of padding operation, but no extra credit will be given for this.
  - The output of your program must be a modified image having the *same size* as the original.
  - You must verify the proper operation of your image mask/filtering program *before you proceed* to processing the image of Figure 3.63(a). To standardize this testing and make it easier for you and for me, I've created two test images which reside in the file `iptest_im.mat` which is also loaded on the "Images" section of the course website. There are five test images in this file, but only two are intended for this project. One test image is 16×16 and is called `iptest16a` and the other is 256×256 and is called `iptest256a`. Run a 3×3 unweighted averaging mask on the two test images and show the resulting filtered images. Also show a small (9×9) subset of actual pixel values (in a numerical table or array) from an appropriate place in each filtered image and mathematically verify that the averaging operation is working correctly on a few[2] appropriate pixels. You don't have to include in your report any other pixel values or the test image results of any other filter mask; I leave that up to you to verify for yourself.

[1] These figures are also shown in toward the end of lecture slides `chap3part5`.

[2] Don't bother calculating all 81 pixel values in the 9×9 region! Just pick a few key representative locations.

- Once your image mask/filtering program has been verified by you as working correctly, load `bones.mat` and proceed to the task of reproducing, using your own original code, each of the image enhancement steps that are depicted in Figure 3.63(b)–(h) of your textbook.

Questions/Discussion: The write-up for this project report should be concise, using wording and formatting suitable for an IEEE technical journal.[3] Be sure to include sufficient figures in your report (with numbered descriptive captions) of any images you create, modify, or that otherwise show results of your code. If you aren't sure if you should include it as a figure, then you probably should include it! Also, don't make image figures too small just to fit more on a page, and ensure that the font size used for figure titles and axis labels is large enough (similar to the font size in your text). The figures need to be large enough so that a printed version of your report would show the important details of the image.

As a minimum, address these points in your project report.

❶ Briefly discuss each image enhancement step you took to reproduce the results of Figure 3.63(b)–(h) in your textbook.

- What was the intended purpose of that step?
- How well did that step achieve its purpose?
- **Don't forget to include this:** What coefficients did you use for the filter mask (or masks) in that step, and why should those coefficients produce the intended result (i.e., what approximate mathematical operation results from using that particular mask or masks)?

❷ Overall, how well did all of the steps, taken together, enhance the image?

❸ Are there any "lessons learned" from this project that you would want to tell to a colleague who was about to try this sort of image enhancement for the first time?

Turn in: For this Project, turn in (as one or more e-mail attachments sent to me as part of a single e-mail message):

➪ An electronic project report (as a PDF file regardless of the program used to create the report). Name your PDF file "`Last1_Last2_proj03.pdf`" please, where "Last1" is the last name of team member 1, and "Last2" is the last name of team member 2. Be sure to follow the format given on the course web site (see the `Admin` section of the course web site).

➪ Any MATLAB m-files you created for this project. There is no need to send me any data or image files that you generated. I'll run your m-files and generate the resulting images myself. If for some reason I need additional files from a particular student, I'll request them separately.

As always, get an early start on this assignment if you want to do a good job. Don't wait until the due date approaches to get started!

❄❄❄ Enjoy. . . ❄❄❄

[3] Your team's project report must follow the format referenced on the course web site. Be sure to use proper grammar and logical, organized sentences. **Any equations in your report should be typeset with an equation editor** (or use the math mode of LaTeX). All figures and tables should have descriptive numbered captions.