Purpose: Gain familiarity with using MATLAB for simple image processing tasks on color images: color model conversions, smoothing, enhancement, and "green screen" techniques.

Procedure: Submit your report to me as a PDF file via e-mail attachment, along with your MATLAB m-file(s) that you wrote. Be sure to read the report format instructions on the web page.

For *each* MATLAB m-file you write, be sure to comment the code sufficiently, and include initial comments as a crude help system. That is, if a user types "help" followed by your m-file name, comments will print on the screen which tell the user what the program does, what the proper syntax is to use the program, and any other useful tidbits. No Image Processing Toolbox programs should be used; use the low-level MATLAB routines `image` and `axis` to display the images.

For all images in your figures, 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 equal.[1] The x-axis is for the rows and the y-axis is for the columns. Be sure to include numbered descriptive captions for each figure, and make each figure sufficiently large to show the necessary detail on a printed page.

There are many figures (a minimum of 11) you'll need to create as part of this project, so to help you keep it all straight there are diagrams at the end of this document that depict what each of your figures should display. Remember, to properly *display* a color image on a monitor, the image needs to be RGB. If you include some additional figures in the background section of your report, then offset the figure numbers given below by the appropriate number.

1. Create a test image in MATLAB of size 256×256, equivalent to Figure 7.43(h) in your textbook.

2. Show a figure (**Figure 1**) that contains four subfigures[2] related to your test image in a 2×2 format. Show the full RGB version of your test image in the upper left subfigure, and each individual RGB component (displayed as grayscale) in the remaining three subfigures. The main figure caption should clearly identify each subfigure (e.g., "...upper right is the R component...").

3. Using *your own* conversion routines, convert your test image to the HSI color model and to the YCbCr color model. **Figure 2 and Figure 3:** For each of the two figures, show four subfigures in a 2×2 format, similar to Figure 1. Show the original RGB version each time in the upper left and each individual component for the HSI (in Figure 2) and YCbCr (in Figure 3) color models (with the components displayed as grayscale) in the remaining three subfigures. The main figure captions should clearly identify each subfigure. Note: at this point in the project you should have numerically verified some appropriate pixel values to **be sure** your conversion routines are working properly. This would also be a good time to also use the test image to also check your conversion routines in the other direction and numerically verify they also are working properly, since you'll need to convert in both directions, and using a simple test image to verify proper operation is the best approach.

4. Create another $N \times N = 256 \times 256$ test image that shows red, green, and blue squares in the Bayer pattern mosaic shown on the lesson slides (`Chap7part1.ppt`); to start the pattern, make the upper left corner a blue square for consistency across all teams. Each individual square should be sized

[1] Investigate the options of the `axis` command to help you do this.

[2] Consider using the `subplot` command in MATLAB or the `subfig` package in LaTeX.

$N/8 = 32$ pixels across and down. You may want to use the `repmat` command to make the creation of this test image rather easy.

5. Repeat steps 2 and 3 for the Bayer pattern test image. This will result in **Figures 4, 5, and 6**, which will show the RGB, HSI, and YCbCr components, respectively, of the Bayer pattern test image.

6. **Color image smoothing:** Apply a 9×9 unweighted averaging filter on the Bayer pattern test image, using zero padding to deal with edge effects. Perform this operation three times in three different color models (RGB, HSI, and YCbCr) in an appropriate manner for that particular color model. **Figure 7:** Show the original RGB image in the upper left corner. In the remaining three subfigures, show the full color results (in RGB for display) of smoothing using the three different color models.

7. Import the 512×512 color image `lena_color_512.tif` from the Files→Images directory of the course website into your MATLAB workspace. This image is also included in the MAT file named `lena_color.mat` in the same location. For your **Figure 8 and Figure 9**, show the equivalent of your Figure 1 (RGB) and Figure 2 (HSI) except using the Lena image. Your Figure 8 and Figure 9 should look similar to (but probably not identical, due to publisher tweaking) the textbook's Figure 7.36 and 7.37.

8. **Color image enhancement:** Many people have commented that the standard color Lena image looks "too orange," in particular having a rather unnatural skin tone. Use any processing steps you like (use only basic MATLAB commands—no Toolboxes or other programs), in any color model(s) you like, in an attempt to achieve a more natural and pleasing skin tone for the Lena image. Your **Figure 10** should show two subfigures side by side, the original on the left and your modified version on the right.

9. **Green screen techniques:** Load the file `green_screen.mat` from the Files→Images directory of the course website into your MATLAB workspace. This file contains two color images: 1) `AFA` is a 1312×2000 photograph taken at the U.S. Air Force Academy (Colorado), showing the Terrazo area, the Academy chapel, and the front range foothills; 2) `F16` is a 466×720 photograph of an F-16C assigned to the U.S. Air Force Thunderbirds aerial demonstration team, taken at Point Magu Naval Air Station on the coast of California (just north of the Los Angeles area). The `F16` image has had the original backround removed and substituted with a highly saturated green hue, to simulate a "green screen" effect. The required task is to create a composite image (which you will show as **Figure 11**), using green screen techniques, that makes it appear as if the F-16C is flying over the Air Force Academy. Specifically, the aircraft should appear in the upper right area of the `AFA` image. Take into account any adjustments needed to the relative size of the aircraft with respect to the new background, such that the new image appears realistic.

Questions/Discussion: As a minimum, address these points in your project report.

- ➪ Include specific examples of how you verified correct operation of all your conversion routines to/from each of the color models.

- ➪ For Figures 1–6, comment briefly on why (or why not) the individual components of the two test images in each color model "make sense." That's is, from your comments I should be assured that you understand what those individual components are telling you, and that the component values are appropriate for that image in that particular color model.

- For Figure 7, briefly explain your results of the smoothing operation in each color model. Did you get the results you expected? Comment on any "color shifts" you can see in the smoothed test image, and state which color model would you usually choose for a smoothing operation, and briefly defend your choice.
- For Figures 8 and 9, how do your results compare to Figure 6.38 and 6.39 in your textbook?
- For Figure 10, specifically describe each step you took to enhance the Lena image, why you took those steps, and evaluate your result.
- For Figure 11, specifically describe each step you took to produce the composite green screen image, why you took those steps, and evaluate your result.
- Overall, what did you learn or what can you conclude after performing the tasks of this project? Only serious answers will be accepted.

Turn in: Turn in your project report in PDF file format, along with any original m-files you wrote as part of this project as separate files, via e-mail attachments. Your team's project report must follow the format on the course web site. Be sure that the name of each team member appears on the first page of the report (below the title of 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.

Don't try to get too fancy on this assignment. More pages do *not* necessarily translate into a higher grade! The written part should be brief, clear, and concise.[3]

See the next page for a graphical representation of the various figures to be generated.

[3]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 or tables should have numbered descriptive captions.

Note: Fig. 1 is similar to Fig. 7.43(e)-(h) in the text

test image

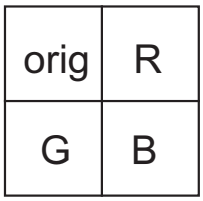

Fig. 1

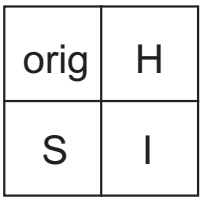

Fig. 2

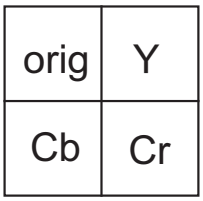

Fig. 3

Bayer image

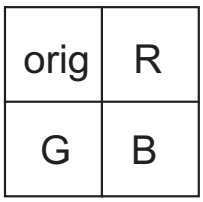

Fig. 4

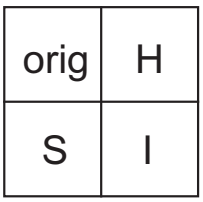

Fig. 5

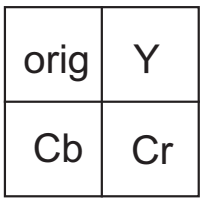

Fig. 6

Bayer image

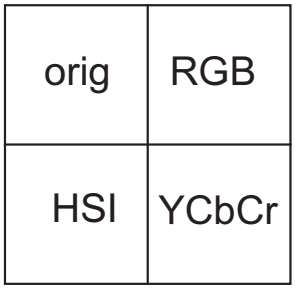

Fig. 7

Results of SMOOTHING in each color model shown, all displayed in RGB

Lena image

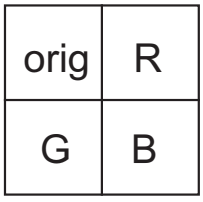

Fig. 8

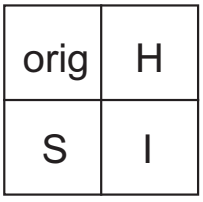

Fig. 9

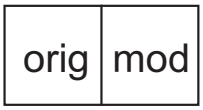

Fig. 10

Green screen image

Fig. 11