

345 Digital Image Processing

2010

Exercises

Exercise 1-1 — Macro recording

A convenient way to document what you are doing in ImageJ is to record everything with the *macro recorder*. “Playing back” a recorded macro allows you to repeat the operations you have done. This is actually often useful when you have made a mistake and ImageJ’s limited “Undo” capability cannot save you – then you can quickly re-establish the state from before your mistake by running the relevant steps of the recorded macro.

It is expected that you use the recorder to document every exercise. This first exercise takes you through the steps needed.

(1) Start ImageJ. Activate the macro recorder from the menu: *Plugins, Macros, Record...*

This will open the recorder window. Leave the window open while you perform the following operations.

(2) Open the sample image *Embryos* (*embryos.jpg*). Convert the image to greyscale by selecting *Image, Type, 8-bit* from the menu. View the histogram (*Analyze, Histogram* from the menu or keyboard shortcut CTRL-H). Close the histogram window. Notice how the operations you performed are documented in the macro recorder window.

(3) Duplicate the image to create a new image window by selecting *Image, Duplicate...* from the menu or using keyboard shortcut CTRL-SHIFT-D. Do not change the suggested title (*embryos-1.jpg*). Invert the duplicate image by selecting *Edit, Invert* from the menu or using keyboard shortcut CTRL-SHIFT-I.

Switch back and forth between the two image windows by clicking on their title bar. Notice how this *is not* recorded by the macro recorder.

Now switch back and forth between the two image windows by selecting them from the *Window* menu. Notice how this *is* recorded. Generally when you are working with multiple windows you have to think about which image window is active when you perform an operation and when you change active window you must use the *Window* menu to get it recorded.

Close both image windows.

Image Analysis

(4) Now create a macro text editor window from the recorded macro. To do this, switch to the macro recorder window, enter the name “Exercise 1-1” and press the button *Create*.

In the macro text editor menu you can edit the macro text, you can save the text to a file and you can run the macro or parts of it.

(5) Place the text cursor on the first line in the macro editor window (the line opening the *Embryos* image). Evaluate this line by selecting *Macros, Evaluate Line* from the window menu or typing `Ctrl-E`. The image window should appear.

Select/mark the next two lines (converting the image to greyscale and opening the histogram image) either by mouse drag or holding down `SHIFT` and using the arrow keys. Press `Ctrl-E`. Both lines should be evaluated.

Close the histogram and the image.

Select/mark the first three lines. Run them by selecting *Macros, Run Macro* from the macro editor window menu.

Close the histogram and the image.

Now run the entire macro by making sure that no text is selected in the macro editor window and pressing `CTRL-R`.

(6) Edit the macro text, inserting the following as a new first line:

// Playing around with the macro recorder

Lines starting with double slashes `//` are comments and have no effect when the macro is run (verify this by running the macro again).

Comments are useful to remind yourself (or your instructor) what certain operations are supposed to achieve.

(7) Save the macro text by selecting *File, Save As...* from the editor window menu. Make certain you save the text file in the directory you created for the exercises and *not* in one of the ImageJ directories.

Exercise 1-2 — Enhance Me (I)

Open the sample file *Enhance Me* (`enhance-me.gif`).

Examine the histogram (*Analyze, Histogram* from the menu or keyboard shortcut `CTRL-H`).

(1) Duplicate the original image to create a working image window (*Image, Duplicate...* from the menu or keyboard shortcut `CTRL-SHIFT-D`).

Normalize the histogram (*Process, Enhance Contrast, Normalize*). Set the saturated pixel percentage to 0.

Examine the histogram.

(2) The “salt” and “pepper” pixels prevent the use of the entire greyscale range. Pixel values above 28 or below 2 in the original image are noise. Find these values by examining the histogram of the original image (slide the mouse cursor over the histogram to the the pixel counts for the different grey values).

To get a better normalization we want to transform input pixel values I_i to output pixel values O_i as follows:

$$O_i = \frac{255}{28 - 2}(I_i - 2) \approx 9.808(I_i - 2)$$

Duplicate the original image to create a new working image window.

Use the operations in the *Process, Math* menu to carry out the pixel value transformation above.

Examine the histogram of the transformed image.

Image Analysis

(3) Now use the *Image, Adjust, Brightness/Contrast* window (CTRL-SHIFT-C) to carry out the same transformation as before, on the original image. Start by pressing the *Auto* button and then adjust minimum to 2 and maximum to 28. Apply the transformation by pressing the *Apply* button.

Verify that the image is now identical to the one created in (2) above. Do this by subtracting the two images (with *Process, Image Calculator...*) and examining the histogram of the resulting image (all pixels should be zero).

We shall get rid of the salt and pepper noise in the *Enhance Me* image in a later session.

Exercise 1-3 — Lookup tables

For one channel (i.e. not colour) images, ImageJ uses a *lookup table* (LUT) to translate pixel values to displayed values. Changing the LUT will change the appearance of the image without changing the actual pixel values. The LUT is saved with the image when you save it (for image formats that support it).

(1) Open the file `enkelt008.tif` (is in the session ZIP file). View the image histogram (CTRL-H). Do not close the histogram image, but do select the image window again.

(2) Change the LUT to a more colourful one with *Image, Lookup Tables, Fire*. Create a new histogram window. Notice that the histogram is unchanged, except for the bar showing the LUT.

(3) “Reset” to the standard LUT with *Image, Lookup Tables, Greys*. Invert the LUT with *Image, Lookup Tables, Invert LUT*. Verify that the pixel values are unchanged (look at the histogram). Invert the pixel values with *Edit, Invert* (CTRL-SHIFT-I). Verify that the LUT is unchanged. Reset the LUT to *Greys*.

Optional: Exercise 1-4 — Image types

The purpose of this exercise is to understand how the different one channel image types are displayed and converted in ImageJ.

Open the sample file *Enhance Me* (`enhance-me.gif`).

(1) Duplicate the image to create a new working image. Convert to 32 bit floating point format with *Image, Type, 32-bit*. The image appearance changed. Have the pixel values changed? Explain, bearing in mind that the display hardware supports only 8 bit greyscale...

(2) Convert back to 8 bit format. The image appearance is unchanged. Have the pixel values changed? Explain...

(3) Duplicate the original image to create a new working image. Convert to 16 bit format with *Image, Type, 16-bit*. The image appearance changed. Have the pixel values changed? Explain...

(4) Multiply all pixel values with 100 by using *Process, Math, Multiply...*. Then add 10000 to all pixel values with *Process, Math, Add...*. Does the appearance change? Explain...

Duplicate the image for use in question (6) below.

(5) Which result do you expect we get if we convert back to 8 bit format (appearance and pixel values)? Do the conversion and verify.

Image Analysis

(6) Select the 16 bit format image you created in question (4) above. Duplicate it and convert the duplicate to 32 bit floating point. Did the pixel values change?

Now subtract 30000 from the pixel values, first in the 32 bit image and then in the 16 bit image. Explain the difference.

Finally convert the 32 bit image to 16 bit format. What happened to the pixel values?