INTRODUCTION TO DIGITAL IMAGE PROCESSING

ASSIGNMENT 2

Due date: Thursday, October 18, 2018 by 5 pm
Total marks: 5
Late penalty: 0.5 marks per day overdue. Late assignments will not be accepted after 5 pm on Monday, October 22, 2018, and a mark of zero will be given.

All assignments will be done in **groups** of 3-4, and the same final mark for the assignment will be assigned to all group members. Instructions for forming a group in OWL are given in Appendix A, but we prefer that you keep the same group as in Assignment 1.

Instructions for submitting answers are given with each question below. Note that I allow you to keep resubmitting until the deadline. Only the last submission is available to the TAs for marking. I recommend that all group members should agree to a submission before uploading it.

CONVENTIONS

Fixed-point font (`Courier`) is used to denote MATLAB commands, variables and filenames.

OBJECTIVE

To implement a function for automatically finding a threshold for binarizing an image.
(Although MATLAB has such a function, `graythresh`, the algorithm implemented as part of this assignment is different. There are sometimes many solutions to the same problem.)

PROBLEMS

Write a MATLAB function called `intermeans_#` that implements the intermeans algorithm described in Appendix B. In the function name, # refers to your group number, e.g., `intermeans_7` for Assignment Group 7. The intermeans algorithm is used to automatically find a threshold to binarize an image. The function should accept a `uint8` intensity image, `im`, and should return as output a scalar normalized threshold called `thres` that is between 0.0 to 1.0. The function header should be:

```
function thres = intermeans_#( im )
```

Use only the following MATLAB keywords, functions and operators:

```
function, imhist, Inf, round, mean2, while…end, abs, sum
```

and any other operator found by typing:

```
help ops
```

No other MATLAB functions are allowed.

All code and answers requested below must be submitted using OWL. To provide answers via OWL:

1. **One group member should log into OWL and select "ECE 4445A 001 FW18".**
2. **From the left-hand side, select "Assignments".**
3. **From the page that comes up, select "Assignment 2".**

4. **You will now reach the submission page for Assignment 2. Follow the instructions below for each part to submit answers.**

(a) **[4.5 marks]** Save the function in a file called `intermeans_#.m` where # is your group number. For instance, if you are part of Assignment Group 1, your filename would be `intermeans_1.m`. If you are part of Assignment Group 17, your filename would be `intermeans_17.m`. **NOTE: Use the exact filename and function name as specified above. Uppercase/lowercase is important. Your function should be commented.**

When you are on the submission page in OWL for Assignment 2, scroll to the bottom and attach your M-file. Also, cut and paste this code into the text box taking care to label this as part (a).

(b) **[0.1 marks]** Apply your function `intermeans_#` to the image `rice.png` that is included in the MATLAB image processing toolbox. What value does `intermeans_#` return? **Write your answer in the text box on the submission page for Assignment 2 taking care to label this as part (b).**

(c) **[0.1 marks]** Use the built-in MATLAB function `im2bw` to create a binary image `bw` using the threshold value determined in part (b), and look at `bw` using the `imshow` function. You should note that some grains of rice are lost in the binarization process. Why are they lost? **Write your answer in the text box on the submission page for Assignment 2 taking care to label this as part (c).**

(d) **[0.1 marks]** Using the `bwlabel` function without the 2nd input argument, get MATLAB to count the number of rice grains in the binarized image `bw` generated in part (c). State what you typed at the MATLAB prompt to calculate the number of grains. State how many grains were counted. **Hint:** I want you to become accustomed to using the `help` command. **Write your answers in the text box on the submission page for Assignment 2 taking care to label this as part (d).**

(e) **[0.2 marks]** There will be some spots in the binarized image `bw` that do not correspond to actual rice grains, but arise because of noise in the image. Using the `help` command, give a brief summary (i.e., no more than 3 sentences; no run-on sentences) of what the command `bwareaopen` does. Using the 2-argument version of the `bwareaopen` command, apply it to the binary image `bw` to produce another binarized image called `bw2` in which these spots are mostly eliminated; use 5 for the second input argument. Using `bwlabel`, count the number of grains and state it in your submission. **Write your answers in the text box on the submission page for Assignment 2 taking care to label this as part (e).**

In the text box on the assignment submission page, enter the name and student number of each group member.

MATLAB RESOURCES

All MATLAB guides can be found at:

http://www.mathworks.com/access/helpdesk/help/helpdesk.shtml

which can also be accessed by typing `doc` at the MATLAB prompt. For information on the image processing toolbox, select the link labelled "Image Processing Toolbox".

APPENDIX A

Step 1: Log into OWL and click on Site Info. Click on the section near the bottom labelled Groups you can join**.** There should be a list of 50 potential groups to join. These are called "Assignment Group 1", "Assignment Group 2", …, "Assignment Group 50".

Step 2: Once a student joins a group you will see his/her name under **Members**. If you see your partner's name in a group, join that group by hitting the "Join" button. If you don't see your partner's name, join **any** empty group; when your partner goes to join a group they will see your name and join yours. If you joined the wrong group, you can leave or un-join the group.

APPENDIX B

The intermeans algorithm was proposed by Ridler and Calvard (1978), and is an automatic method for finding a threshold to binarize an image. It is one of many such algorithms. A survey of automatic threshold determination algorithms is given by Glasbey (1993). The intermeans algorithm works as follows.

1. Make an initial guess at the threshold value *T*. For example, you can take *T* to be the mean gray level value of the entire image rounded off to the nearest integer.
2. Calculate the mean gray level of pixels that are less than or equal to *T* using the formula:

$$\mu_1 = \frac{\sum_{D=0}^{T} Dh(D)}{\sum_{D=0}^{T} h(D)}.$$

Also calculate the mean value for pixels with gray levels greater than *T*:

$$\mu_2 = \frac{\sum_{D=T+1}^{D_{\max}} Dh(D)}{\sum_{D=T+1}^{D_{\max}} h(D)},$$

where D_{max} is the maximum gray level for the data type (255 for `uint8`). Note *D* refers to gray levels (0, 1, …, 255) and *h*(*D*) is the histogram of the image.

3. Re-estimate *T* as half way between the two means, i.e.,

$$T = \left[\frac{\mu_1 + \mu_2}{2}\right],$$

where [ ] denotes that the result should be rounded off.

4. Repeat steps 2 and 3 until *T* stops changing value between consecutive evaluations.

REFERENCES

You do not need to read the references below. They are provided in case you are interested in finding out more about threshold determination.

[1] Ridler, T. and Calvard, S. (1978). Picture thresholding using an iterative selection method. *IEEE Transactions on Systems, Man and Cybernetics*, **8**, 630-632.
[2] Glasbey, C.A. (1993). An analysis of histogram-based thresholding algorithms. *CVGIP: Graphical Models and Image Processing*, **55**, 532-537.