ID2090 : Introduction to Scientific Computing
Summer-2021

Final Evaluation

You are welcome to use any programming paradigm you are comfortable to attempt the following questions. Your submission will be a tar file that contains your report and any code that goes with the work. Don't forget to provide your name, roll number and question number on the first page of each report. Make a tar of your stuff, name it with your roll number (eg., ME20B001-final.tar) and upload on moodle (https://courses1.iitm.ac.in which contains this course and not the new server at https://courses.iitm.ac.in for upcoming semester).

Each question carries 12 marks. Remaining 6 marks are for presentation of the report, quality of write up, attribution of any references made and overall effort as indicated by the code.

[1] Consider a symmetrical natural shape such as what is shown in the figure below. Utilize the

contrast difference between the shape (flower in this case) and the background (green leaves in this case) to determine the contour of the shape. Convert the contour to a set of points that represent the outer form of the shape. Fit a function such as $r(\theta)$ to unwrap the shape to a linear function of the angle in the polar form. You can utilize step functions or splines or a combination of any elementary mathematical functions to fit. Plot the function and show it side-by-side with the original image to confirm that the procedure is able to capture the shape correctly. Compare the size of the original image (bytes) with the data required to store the function (bytes) and comment on the compression ratio achieved. Comment also on the possibility of determining the symmetry of the image from this exercise. Eg., the above image has a 8 fold rotational symmetry. Test your code by using any other image of a symmetrical flower taken from the internet.

Application: Image compression for the purpose of comparison of similar images is an important aspect of image recognition. If this were to be done in a video, the size and speed matter a lot given that large number of images that need to be processed in real time. Recognizing symmetry in an object is non-trivial if the angle of view is not along the axis of symmetry.

[2] Consider a function of a form such as $\mathrm{g(x)} = \mathrm{A}_1 + A_2 \exp(-A_3\, x)$ where $A_1, A_2,$ and A_3 are constants. Assuming **random** values for these three constants, generate the values of the function g_i for a set of input values x_i that lie in the interval between 0 and 5. Make a scatter plot of $(x_i,\, g_i)$ which can be taken as the experimental data. You can consider the number of values to be 50, to be representative.

Add a random noise δ_i of amplitude 5% of the maximum value of this set g_i to each of the values. The random noise can be either positive or negative. The data thus generated will be $(x_i,\, g_i + \delta_i)$. Now, fit the same function $h(x) = B_1 + B_2 \exp(-B_3\, x)$ as a model using this input data. Superpose the original function and the fitted function to confirm that the fitting process was reasonable. Comment on the difference between the initial values of $A_1, A_2,$ and A_3 with those of $B_1, B_2,$ and B_3 obtained from the fit.

Change the amplitude of the noise from 5% to 7% and then 10% to see if it has any influence on the differences $(A_1 - B_1), (A_2 - B_2),$ and $(A_3 - B_3)$. Comment on the trend.

Application: Experimental data usually has a noise. One should fit experimental data only to those mathematical forms / models that have some physical significance with the phenomena associated with those experiments. Error in the parameters of the models can be reduced if more information is available about the physical phenomena.

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