

CE7453 Numerical Algorithms

Assignment 1 (Interpolation using cubic B-spline curves)

A good way to develop a working knowledge is to actually write programming codes. This assignment is to write a program using any programming language such as C/C++, Python, Java, and MATLAB that you prefer to use. The program implements the cubic B-spline interpolation algorithm introduced in Module 5 (topic: cubic B-spline interpolation). The program accepts an input file that contains a set of 2D points (at least 4 points), outputs a cubic B-spline curve, and displays the input data points and the resulting B-spline curve as well.

The input file is in the following format:

```
x0 y0  
x1 y1  
x2 y2  
...  
xn yn
```

where x_i, y_i are the x- and y-coordinates of the $(i+1)^{\text{th}}$ point, respectively.

The output B-spline curve should be in the following format

```
3  
cnt_num  
u0 u1 u2 ...  
x0 y0  
x1 y1  
...
```

where “3” represents the degree of the B-spline curve, “cnt_num” is the number of the control points, “u0, u1, ...” are the knots of the curve, “x0 y0” are the x- and y-coordinates of the first control point, “x1 y1” are the x- and y- coordinates of the second control point, and so on.

The file “cubic.txt” below is an example file of a cubic B-spline curve with 4 control points (0,0), (10,50), (30,10) and (100,100). We can see that this curve’s parameter domain is [2,3].

cubic.txt ---

```
3
4

0    0.5  1  2  3  3.5  4.5  5

0    0
10   50
30   10
100  100
```

What you are supposed to do for this assignment are as follows:

- 1) (40 marks): Implement the cubic B-spline interpolation algorithm correctly.
- 2) (10 marks): Write the linear equations explicitly for the following input data file:

```
0  0
0  2
2  2
2  0
4  0
```

You can derive the linear system manually or you can use your implemented program to find out the linear system.

- 3) (15 marks): Construct two examples with at least 10 data points to test your program. Show the input files and output files, and display the resulting curves together with the input data points.
- 4) (15 marks): Make your program be able to display the input points and the constructed B-spline curve as well. Other enhancements such as GUI are also encouraged. In case you do not want to do this part, you can use other software tool(s) to display the B-spline curves your program outputs. Then you will not receive the marks of this part.
- 5) (20 marks): Write a report which includes
 - the linear system required in item 2).
 - the input and output files of the two examples required in item 3), and the snapshots of the interpolating curves.
 - some discussions about what will happen for the following two cases: (i) the number of the input data points is less than 4; and (ii) there are two points in the input point list have the same coordinates.

Note: The total 100 marks of this assignment will contribute to 20 marks in the final grade. The total 100 marks of the second assignment will contribute to 30 marks in the final grade.

Submission instruction:

- Create a folder and name it **exactly as your name** that is written on your matriculation card. Then under this folder, further create two sub-folders named “**assignment1**” and “**assignment2**”.
- Copy your **report** and **source code**, to folder “assignment1”.
- Sub-folder “assignment2” is for Assignment 2.
- After you complete the two assignments at the end of the semester, zip the folder. Go to the NTULearn course-site. Within the **Assignments** you will find **CE7453-Projects**, where you submit the zipped file.

Submission deadline: 18 April 2022 (Monday)