Numerical Anaylysis Projects

Say OL

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Each group project/assignment must choose one and only one of the following topics:

1 TOPIC 1: System of Nonlinear Equations

In the course, we confined our attention to solving the single equation $f(x) = 0$. Let us now consider the n-dimensional version of the same problem, namely,

$$\mathbf{f(x) = 0}$$

or, using scalar notation

$$f_1(x_1, x_2, \ldots, x_n) = 0$$
$$f_2(x_1, x_2, \ldots, x_n) = 0$$
$$\vdots$$
$$f_n(x_1, x_2, \ldots, x_n) = 0$$

Solving n simultaneous, nonlinear equations is a much more formidable task than finding the root of a single equation. The trouble is there is no a reliable method for bracketing the solution vector $\mathbf{x}$. Therefore, we cannot always provide the solution algorithm with a good starting value of $\mathbf{x}$, unless such a value is suggested by the physics of the problem.

The simplest and the most effective means of computing $\mathbf{x}$ is the Newton-Raphson method. It works well with simultaneous equations, provided that it is supplied with a good starting point. There are other methods that have better global convergence characteristics, but all of then are variants of the Newton-Raphson method.

What to do

1. White a theoretical liturature review about the Newton-Raphson method for system of nonlinear equations.

2. White the algorithm and/or pseudocode of the method.

3. Develop python programming code for the algorithm.

4. Give illustrating example(s) with solution(s) obtained from the developed code.

Some helpful references

1. https://courses.engr.illinois.edu/cs357/fa2019/references/ref-11-solve-nd/

2. http://home.iitk.ac.in/~pranab/ES0208/rajesh/03-04/Nonlinear.pdf

2   TOPIC2: Monte Carlo integration

We all remember the integrals we had to compute manually in high school. To do so, we had to compute a series of more or less complex operations to find the antiderivative functions' expressions before applying substraction through the desired interval. However, you may also remember that integrating a function is graphically equivalent to calculating the area under the curve of that function. The principle of numerical integration lies on this second statement. The idea is to estimate the integral of a function, over a defined interval, only knowing the function expression. For such an aim, Monte Carlo methods are a great help. Monte Carlo integration is a technique for numerical integration using random numbers.

What to do

1. White a theoretical liturature review about the Monte Carlo integration.

2. White the algorithm and/or pseudocode of the method.

3. Develop python programming code for the algorithm.

4. Give illustrating example(s) with solution(s) obtained from the developed code.

Some helpful references

1. https://en.wikipedia.org/wiki/Monte_Carlo_integration

2. https://towardsdatascience.com/the-basics-of-monte-carlo-integration-5fe16b40482d

3. https://www.scratchapixel.com/lessons/mathematics-physics-for-computer-graphics/monte-carlo-methods-in-practice/monte-carlo-integration.html

3   Numerical Method with R Programming Language

As suggested by some of your classmates, they may probably want to try a flavor of R programming language instead of Python. The objective of this topic is to give you an oopportunity of mastering R programming skill.

What to do

1. List all algorithms in our course.

2. Write some tutorials about R programming which are relevant the most to the problems in numerical analysis as we have done in Python.

3. Write R programming codes for all of above algorithms.

4. Compare the two programming languages in the scope of numerical analysis.

Some helpful references

1. https://www.r-project.org/other-docs.html

2. https://en.wikibooks.org/wiki/R_Programming/Documentation

3. https://www.cambridge.org/core/books/numerical-analysis-using-r/F960FEA38747541F1C5

4. https://www.routledge.com/Using-R-for-Numerical-Analysis-in-Science-and-Engineering
   Bloomfield/p/book/9781439884485

4   Numerical Method with R Programming Language

As suggested by some of your classmates, they may probably want to try a flavor of C++ programming language instead of Python. The objective of this topic is to give you an oopportunity of mastering C++ programming skill.

What to do

1. List all algorithms in our course.

2. Write some tutorials about C++ programming which are relevant the most to the problems in numerical analysis as we have done in Python.

3. Write C++ programming codes for all of above algorithms.

4. Compare the two programming languages in the scope of numerical analysis.

Some helpful references

1. https://faculty.engineering.asu.edu/rajan/object-oriented-numerical-methods-via-c/

2. https://www.bragitoff.com/2015/11/numerical-analysis-c-programs-for-various-technic

3. https://www.amazon.com/Numerical-Methods-Programming-Nita-Shah-ebook/dp/B01FHAZOUI

4. https://www.udemy.com/course/learn-numerical-methods-using-c/