CSE 4345 – Homework #6

Assigned: Thursday, March 28, 2019
Due: Thursday, April 4, 2019 at the end of class

Note the following about the homework:

1. You must show your work to receive credit.
2. If your submission has more than one page, staple the pages. If I have to staple it, the cost is 10 points.

Assignment:
Process

1. There are numerous ways to solve a system of nonlinear equations. Some methods require an initial guess that is somewhat close to the solution and without a good initial guess may fail to converge.

   Use Newton's method to find a root for the system of nonlinear equations

   $$\begin{aligned} x_1^2 - 2x_2^2 &= -14 \\ 3x_1^2 + x_2^3 &= 39 \end{aligned}$$

   with initial guesses

   (a) $x_0 = (1, -1)^T$
   (b) $x_0 = (-1, 1)^T$

   Use 6 iterations of the algorithm in each case.

   - For at least the first couple of iterations using the first initial guess, show enough of the steps that it is clear you understand the process. Write or type this, don't rely on Numpy's output. After that you can rely on Numpy's output of each of the matrices $\vec{x}_i$, $f(\vec{x}_i)$, $J(\vec{x}_i)$, and $\vec{s}_i$. The point here is to be able to see if the solution is converging.
   - The two initial guesses lead to two different solutions. Which do you think is correct and why?

   The problems above would be painful to do strictly by hand, so you can use Numpy to assist with the math. Don't use any Numpy function that basically just solves a system of nonlinear equations, but you can write a program to carry out the steps of the algorithm.

   Show enough of the steps that someone (e.g., your future self) looking at your work could understand the process. Remember that you will have to do this by hand on the exam, so do the work and transcribe the process in such a way that you are preparing for that.

2. (Python program) Reproduce the robotic arm example in [Fau03], which gives the necessary equations, with the values given here.

(a) The relevant pages from [Fau03] are uploaded to Blackboard.

(b) On the course website is a skeleton file, `roboticArm.py`, that you will use. At the bottom of the file are the lines

```
if __name__ == "__main__":
    positioning(0.7, 0.7, math.sqrt(29), math.sqrt(10), 6, 5)
```

You will place your code in the function `robot()`. The line

```
if __name__ == "__main__":
```

allows you to execute `roboticArm.py` while also allowing the function `positioning()` to be imported by another program. This will allow me to call your function with my own arguments.

(c) Find α and β if $d_1 = \sqrt{29}$, $d_2 = \sqrt{10}$, $p_1 = 6$, $p_2 = 5$. Use an initial value of $\vec{x}_0 = [\alpha, \beta]^T = [0.7, 0.7]^T$.

(d) Use Newton's method and stop after producing $\vec{x}_6$. Note that you will need to use the angle addition formulae to change the trigonometric terms with $\sin(\alpha+\beta)$ and $\cos(\alpha+\beta)$.

(e) For this problem, you don't need to do any parts by hand. Just write a Python program using the Numpy library to solve, but make sure that the output shows the changes in α and β on each iteration.

(f) To give you an idea of what the correct answer is, you can sketch the arms. Initially, the end of d_1 is $(x_1, y_1) = (5, 2)$ and the end of d_2 is $(x_2, y_2) = (6, 5)$. To test your code, you can replicate the example given in [Fau03].

General requirements about the Python problems:

a) As a comment in your source code, include your name.

b) The Python program should do the work. Don't perform the calculations and then hard-code the values in the code or look at the data and hard-code to this data unless instructed to do so.

c) The program should not prompt the user for values, read from files unless instructed to do so, or print things not specified to be printed in the requirements.

To submit the Python portion, do the following:

a) Create a directory using your net ID in lowercase characters plus the specific homework. For example, if your net ID is `abc1234` and the homework is `hw04`, then the directory should be named `abc1234-hw04` (zero-pad the number if necessary to make it two digits).

b) Place your .py files in this directory.

c) Do not submit the data files unless instructed to do so.

d) Zip the directory, not just the files within the directory. You must use the zip format and the name of the file (using the example above) will be `abc1234-hw04.zip`.

e) Upload the zip'd file to Blackboard.

References

[Fau03] Laurene Fausett. *Numerical Methods: Algorithms and Applications*. Pearson Education, Upper Saddle River, NJ, 2003.