Name: Caroline Ta
Course Name: CS3010.01 - Numerical Methods
Assignment: Programming Project 2
Date: 09/28/2020

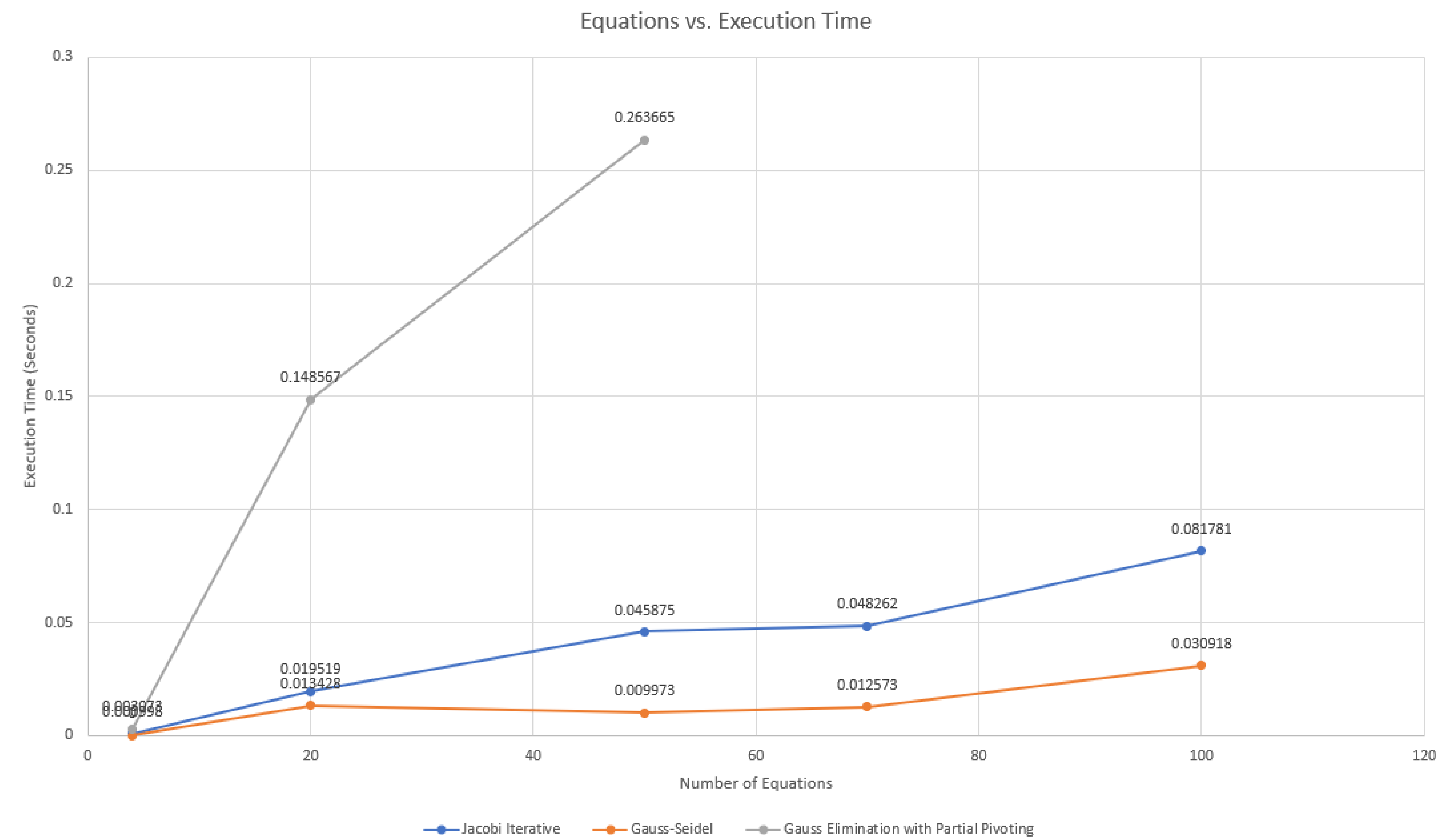
The execution time recorded for each test case is as follows:

Methods	**Number of Equations**				
	4	20	50	70	100
Jacobi	0.0009979999999999	0.0195189999999999	0.0458749999999999	0.0482619999999999	0.0817809999999999
Gauss-Seidel	0.0000000000000000	0.0134279999999999	0.0099729999999999	0.0125729999999999	0.0309179999999999
Gaussian Elimination	0.0030729999999999	0.1485670000000000	0.2636650000000000	6.0957609999999954	17.7830629999999985

Comments:

As the number of equations to solve increases, the execution time also increases. The Gauss-Seidel method is the one with the fastest execution time, and the Gaussian Elimination method with Scaled Partial Pivoting is the one with the slowest execution time. Some problem may occur is that the relative approximate error becomes unchanged or an imaginary number before 50 iterations; the execution time may take much longer based on how many equations we are trying to solve.

I have included a graph below based on the execution time of each method for 4, 20, 50, 70, and 100 equations. However, to see more clearly the significant difference between the execution time of Gaussian Elimination method with Scaled Partial Pivoting vs. Jacobi Iterative method and Gauss-Seidel method, I stop the graph of Gaussian Elimination at 50 equations.


Equations vs. Execution Time
Execution Time (Seconds)
Number of Equations
0.263665
0.148567
0.081781
0.045875
0.048262
0.030918
0.019519
0.013428
0.009973
0.012573
0
0.05
0.1
0.15
0.2
0.25
0.3
0
20
40
60
80
100
120
Jacobi Iterative
Gauss-Seidel
Gauss Elimination with Partial Pivoting

```
********************************************************************************
* Name:       Caroline Ta
* Date:       09.28.2020
* Class:      CS3010.01 - Numerical Methods
* Assignment: Programming Project 2 - Jacobi & Gaussian-Seidel (Extra Credit)
********************************************************************************

Would you like to input the matrix through command line or text file?
[0] - Exit the Program
[1] - Command Line
[2] - Text File

Enter choice: 1

Enter the number of equations: 3

Enter the coefficients:
5 -1 0 7
-1 3 -1 4
0 -1 2 5

Enter the desired stopping error: 0.3

Enter the starting solution: 0 0 0

We have the following matrix:
 5      -1       0       7
-1       3      -1       4
 0      -1       2       5

-----------------------------------------------------------------
                   JACOBI ITERATIVE METHOD
-----------------------------------------------------------------

Iteration #1:   [1.4  1.33333  2.5] T
Error: 1 < 0.3 (False)

Iteration #2:   [1.66667  2.63333  3.16667] T
Error: 0.484061 < 0.3 (False)

Iteration #3:   [1.92667  2.94444  3.81667] T
Error: 0.302472 < 0.3 (False)

Iteration #4:   [1.98889  3.24778  3.97222] T
Error: 0.225357 < 0.3 (True)

[Press Enter to Continue: Gauss-Seidel Method]
```

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-----------------------------------------------------------------
                     GAUSS-SEIDEL METHOD
-----------------------------------------------------------------

Iteration #1:   [1.4  1.8  3.4] T
Error: 1 < 0.3 (False)

Iteration #2:   [1.76  3.05333  4.02667] T
Error: 0.270368 < 0.3 (True)

[Press Enter to Continue: Gaussian Elimination with Scaled Partial Pivoting]

-----------------------------------------------------------------
          GAUSS ELIMINATION WITH SCALED PARTIAL PIVOTING
-----------------------------------------------------------------

Scale vectors: s = [5, 3, 2]

Ratio: r = {1.00, 0.33, 0.00}
The largest ratio found is 1.00 so we choose R1 and swap with R1 (matrix stays the same)

The matrix after R1 <-> R1
5.00    -1.00   0.00    7.00
-1.00   3.00    -1.00   4.00
0.00    -1.00   2.00    5.00

The matrix after scaled partial pivoting:
5.00    -1.00   0.00    7.00
0.00    2.80    -1.00   5.40
0.00    -1.00   2.00    5.00

Scale vectors: s = [5, 3, 2]

Ratio: r = {0.93, 0.50}
The largest ratio found is 0.93 so we choose R2 and swap with R2 (matrix stays the same)

The matrix after R2 <-> R2
5.00    -1.00   0.00    7.00
0.00    2.80    -1.00   5.40
0.00    -1.00   2.00    5.00

The matrix after scaled partial pivoting:
5.00    -1.00   0.00    7.00
0.00    2.80    -1.00   5.40
0.00    0.00    1.64    6.93

The solution of the matrix:
x1 = 2.00
x2 = 3.00
x3 = 4.00

It took the program 0.003988999999999999949 seconds to execute Jacobi Iterative Method.

It took the program 0.003068999999999999968 seconds to execute Gauss-Seidel Method.

It took the program 0.025594999999999999970 seconds to execute Gaussian Elimination with Scaled Partial Pivoting Method.

Thank you for using the program! [Press enter to Close the Program]
```

```
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* Date:       09.28.2020
* Class:      CS3010.01 - Numerical Methods
* Assignment: Programming Project 2 - Jacobi & Gaussian-Seidel (Extra Credit)
*******************************************************************************

Would you like to input the matrix through command line or text file?
[0] - Exit the Program
[1] - Command Line
[2] - Text File

Enter choice: 2

Enter file name: testCase_4.txt

Enter the number of equations: 4

Enter the desired stopping error: 0.4

Enter the starting solution: 0 0 0 0

We have the following matrix:
 7       1      -1       2       3
 1       8       0      -2      -5
-1       0       4      -1       4
 2      -2      -1       6      -3

-----------------------------------------------------------------
                   JACOBI ITERATIVE METHOD
-----------------------------------------------------------------

Iteration #1:   [0.428571  -0.625  1  -0.5] T
Error: 1 < 0.4 (False)

Iteration #2:   [0.803571  -0.803571  0.982143  -0.684524] T
Error: 0.618217 < 0.4 (False)

Iteration #3:   [0.879252  -0.896577  1.02976  -0.872024] T
Error: 0.489871 < 0.4 (False)

Iteration #4:   [0.952912  -0.952912  1.00181  -0.920316] T
Error: 0.43836 < 0.4 (False)

Iteration #5:   [0.970764  -0.974193  1.00815  -0.968307] T
Error: 0.413544 < 0.4 (False)

Iteration #6:   [0.988422  -0.988422  1.00061  -0.980294] T
Error: 0.40198 < 0.4 (False)

Iteration #7:   [0.992804  -0.993626  1.00203  -0.992179] T
Error: 0.396077 < 0.4 (True)

[Press Enter to Continue: Gauss-Seidel Method]
```

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-----------------------------------------------------------------
                     GAUSS-SEIDEL METHOD
-----------------------------------------------------------------

Iteration #1:   [0.428571  -0.678571  1.10714  -0.684524] T
Error: 1 < 0.4 (False)

Iteration #2:   [0.879252  -0.906037  1.04868  -0.920316] T
Error: 0.297735 < 0.4 (True)

[Press Enter to Continue: Gaussian Elimination with Scaled Partial Pivoting]

-----------------------------------------------------------------
          GAUSS ELIMINATION WITH SCALED PARTIAL PIVOTING
-----------------------------------------------------------------

Scale vectors: s = [7, 8, 4, 6]

Ratio: r = {1.00, 0.12, 0.25, 0.33}
The largest ratio found is 1.00 so we choose R1 and swap with R1 (matrix stays the same)

The matrix after R1 <-> R1
7.00    1.00    -1.00   2.00    3.00
1.00    8.00    0.00    -2.00   -5.00
-1.00   0.00    4.00    -1.00   4.00
2.00    -2.00   -1.00   6.00    -3.00

The matrix after scaled partial pivoting:
7.00    1.00    -1.00   2.00    3.00
0.00    7.86    0.14    -2.29   -5.43
0.00    0.14    3.86    -0.71   4.43
0.00    -2.29   -0.71   5.43    -3.86

Scale vectors: s = [7, 8, 4, 6]

Ratio: r = {0.98, 0.04, 0.38}
The largest ratio found is 0.98 so we choose R2 and swap with R2 (matrix stays the same)

The matrix after R2 <-> R2
7.00    1.00    -1.00   2.00    3.00
0.00    7.86    0.14    -2.29   -5.43
0.00    0.14    3.86    -0.71   4.43
0.00    -2.29   -0.71   5.43    -3.86

The matrix after scaled partial pivoting:
7.00    1.00    -1.00   2.00    3.00
0.00    7.86    0.14    -2.29   -5.43
0.00    0.00    3.85    -0.67   4.53
0.00    0.00    -0.67   4.76    -5.44
```

```
Scale vectors: s = [7, 8, 4, 6]

Ratio: r = {0.96, 0.11}
The largest ratio found is 0.96 so we choose R3 and swap with R3 (matrix stays the same)

The matrix after R3 <-> R3
7.00    1.00    -1.00   2.00    3.00
0.00    7.86    0.14    -2.29   -5.43
0.00    0.00    3.85    -0.67   4.53
0.00    0.00    -0.67   4.76    -5.44

The matrix after scaled partial pivoting:
7.00    1.00    -1.00   2.00    3.00
0.00    7.86    0.14    -2.29   -5.43
0.00    0.00    3.85    -0.67   4.53
0.00    0.00    0.00    4.65    -4.65

The solution of the matrix:
x1 = 1.00
x2 = -1.00
x3 = 1.00
x4 = -1.00

It took the program 0.01795099999999999821 seconds to execute Jacobi Iterative Method.

It took the program 0.00487899999999999966 seconds to execute Gauss-Seidel Method.

It took the program 0.03692299999999999749 seconds to execute Gaussian Elimination with Scaled Partial Pivoting Method.

Thank you for using the program! [Press enter to Close the Program]
```