Eso208 PROGRAMMING ASSIGNMENT – 2

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Section – J3

Linear Simultaneous Equation and eigen values

1. Write a computer program for solving a system of linear equations $Ax = b$. The program should have the following features:

Input: The program should read the following inputs from a text file – (i) the number of equations (*n*), (ii) elements of the augmented matrix. [An example of input data file is given].

Options: The user should have the option of selecting one of the following methods–

a. Gauss elimination (GE; without pivoting)
b. GE (with partial pivoting)
c. LU decomposition by Doolittle method (without pivoting)
d. LU decomposition by Crout method (without pivoting)
e. Cholesky decomposition (for symmetric positive definite matrix)

Output: The output from the program should be written in a text file. This file should contain the following results for different methods–

a. GE: the unknowns, *x*
b. LU by Doolittle: the unknowns,*x*, and the elements of L and U
c. LU by Crout method: the unknowns, *x*, and the elements of L and U
d. Cholesky decomposition: the unknowns, *x*, and the elements of L

Solution : a. Gauss Elimination (GE, without pivoting)

INPUT NO OF UNKNOWN VARIABLES3

INPUT 1 FOR GE(without pivoting)

INPUT 2 FOR GE(with pivoting)

INPUT 3 FOR GE(with s&p)

INPUT 4 FOR LU BY GE(without pivoting)

INPUT 5 FOR LU BY GE(with pivoting)

INPUT 6 FOR LU BY CROUT

INPUT 7 FOR CHOLESKY1

INPUT AUGUMENTED MATRIX[4 2 0 10; 2 4 1 11.5; 0 1 5 4.5]

Final Matrix is:

```
   4.0000    2.0000         0   10.0000
        0    3.0000    1.0000    6.5000
        0         0    4.6667    2.3333
```

The Unknowns are:

```
   1.5000
   2.0000
   0.5000
```

b.GE(with partial pivoting)

What do you want to do?

A.Want to solve the system of equation.

B.Want to perform an LU Decomposition.

C.Want to perform a Matrix Inversion.

A

Is the system is tridiagonal?(Y/N): N

```
    4     2     0
    2     4     1
    0     1     5
```

```
   1.5000
   2.0000
```

0.5000

c. LU decomposition by Doolittle method (without pivoting)

What do you want to do?
A.Want to solve the system of equation.
B.Want to perform an LU Decomposition.
C.Want to perform a Matrix Inversion.
B
Is the matrix is symmetric and positive definite?(Y/N): N
4 2 0
2 4 1
0 1 5

Do you want Crout Type (Y) or Dolittle type (N) ?N
L
1.0000 0 0
0.2000 1.0000 0
0 0.5263 1.0000

U
5.0000 1.0000 0
0 3.8000 2.0000
0 0 2.9474

d.LU decomposition by Crout method (without pivoting)

What do you want to do?
A.Want to solve the system of equation.
B.Want to perform an LU Decomposition.
C.Want to perform a Matrix Inversion.
B
Is the matrix is symmetric and positive definite?(Y/N): N
4 2 0
2 4 1
0 1 5

Do you want Crout Type (Y) or Dolittle type (N) ?Y
L
5.0000 0 0
1.0000 3.8000 0
0 2.0000 2.9474

U
1.0000 0.2000 0
0 1.0000 0.5263
0 0 1.0000

3 2
1 2

3 2
1 2

e.Cholesky decomposition (for symmetric positive definite matrix)

What do you want to do?
A.Want to solve the system of equation.
B.Want to perform an LU Decomposition.
C.Want to perform a Matrix Inversion.
B
Is the matrix is symmetric and positive definite?(Y/N): Y
3.0618 0 0
-0.7960 2.7945 0
0.9934 0.7182 2.1635

1 3
1 2

1 3
1 2

2. Write a computer program for finding eigenvalues of a matrix *A*. The program should have the following features:

Input: The program should read - (i) the size of the matrix *A* and its elements, (ii) maximum iterations, (iii) threshold on approximate relative error, and (iv) for inverse power method with shift, the scalar value to which the eigenvalue should be closest.

Options: The user should have the option of selecting one of the following methods–

a. Power method (to find the eigenvalue having the maximum magnitude and the corresponding eigenvector)
b. Inverse power method (to find the eigenvalue having the minimum magnitude and the corresponding eigenvector)
c. Inverse power method with shift (to find the eigenvalue closest to a given value and corresponding eigenvectors)
d. QR method (to find all eigenvalues of a matrix)

Output: The output from the program should be written in a text file. This file should contain eigenvalues and the corresponding normalized eigenvectors (unit length) for options (a) to (c), and only eigenvalues for option (d). Number of iterations required should also be written as an output, *along with the estimate of eigenvalue(s) at each iteration* (note that the iterative sequence is not shown in the sample output).

Note: Use a column vector of appropriate size with each element unity as the guess vector for starting the power methods.

Test Case:

$$A = \begin{bmatrix} 8 & -1 & -1 \\ -1 & 4 & -2 \\ -1 & -2 & 10 \end{bmatrix}$$

Maximum iterations: 50

Maximum relative approximate error: 0.001%

Find Eigenvalue closest to: 8

Sample input file

```
3
8.0     -1.0    -1.0
-1.0     4.0    -2.0
-1.0    -2.0    10.0
100
0.001
8.0
```

a.Power method

```
Whether largest eigenvalue type (L) or all eigenvalues of A type(A) L
Maximum Eigen Value is:
  8.156855423845208

Iterations     6
```

b.QR method

```
Whether largest eigenvalue type (L) or all eigenvalues of A type(A) A
Eigen Values are:
  8.156856061136295   0.656366937948026   0.186780057338391
```

C.Inverse power method

```
z =

   -0.1288
   -0.3396
   -0.9317

  (Error,Eigenvalue) is

value =

   1.0e+03 *

    0.1000    0.0071
    0.1784    0.0035
    1.8103    0.0020
    0.2047    0.0019
    0.2259    0.0019
    0.2008    0.0019
    0.2021    0.0019
    0.2001    0.0019
    0.2004    0.0019
    0.2000    0.0019
    0.2001    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
```

```
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019
    0.2000    0.0019


eigenvalue =

    1.8672

Inverse power method with shift:
z =

    0.9778
   -0.1999
   -0.0624

  (Error,Eigenvalue) is

value =

  100.0000    8.2676
    7.2541    8.2682
    0.5375    8.2682
    0.0472    8.2682
    0.0039    8.2682
    0.0003    8.2682


eigenvalue =

    8.2682
```