1

ECE 2305

Introduction to C Programming

Programming Project 08

Gaussian Elimination

Program Features: Two dimensional arrays, Dynamic Memory Allocation.

Create a C++ program that will find the solution to a set of linearly independent

equations using Gaussian elimination. Write the program in general terms so that it can

be applied to any set of equations. The set of 𝑛 equations have the form

𝑎0,0 𝑥0 + 𝑎0,1 𝑥1 + 𝑎0,2 𝑥2 + ⋯ + 𝑎0,𝑛−1 𝑥𝑛−1 = 𝑏0

𝑎1,0 𝑥0 + 𝑎1,1 𝑥1 + 𝑎1,2 𝑥2 + ⋯ + 𝑎1,𝑛−1 𝑥𝑛−1 = 𝑏1

𝑎2,0 𝑥0 + 𝑎2,1 𝑥1 + 𝑎2,2 𝑥2 + ⋯ + 𝑎2,𝑛−1 𝑥𝑛−1 = 𝑏2

⋮

𝑎𝑛−1,0 𝑥0 + 𝑎𝑛−1,1 𝑥1 + 𝑎𝑛−1,2 𝑥2 + ⋯ + 𝑎𝑛−1,𝑛−1 𝑥𝑛−1 = 𝑏𝑛−1

where 𝑎𝑖𝑗 and 𝑏𝑘 are coefficients that are input by the user and 𝑥𝑘 are unknowns for

which the application will solve.

If the set of cannot be solved (because of a division by zero error), the application should

display a warning message.

A general set of linearly independent equations may be written in the form

[

𝑎0,0

(0) 𝑎0,1

(0) 𝑎0,2

(0) ⋯ 𝑎0,𝑛−1

(0)

𝑎1,0

(0) 𝑎1,1

(0) 𝑎1,2

(0) ⋯ 𝑎1,𝑛−1

(0)

𝑎2,0

(0) 𝑎2,1

(0) 𝑎2,2

(0) ⋯ 𝑎2,𝑛−1

(0)

⋮ ⋮ ⋮ ⋱ ⋮

𝑎𝑛−1,0

(0) 𝑎𝑛−1,1

(0) 𝑎𝑛−1,2

(0) ⋯ 𝑎𝑛−1,𝑛−1

(0) ] [

𝑥0

(0)

𝑥1

(0)

𝑥2

(0)

⋮

𝑥𝑛−1

(0) ]

=

[

𝑏0

(0)

𝑏1

(0)

𝑏2

(0)

⋮

𝑏𝑛−1

(0) ]

An algorithm for Gaussian elimination (written in pseudo-code) is as follows:2

For rows 𝑘 = 0 to 𝑛 − 2, assuming 𝑎𝑘,𝑘

(𝑘) ≠ 0

For rows 𝑖 = 𝑘 + 1 to 𝑛 − 1, define the row multipliers

𝑚 = 𝑎𝑖,𝑘

(𝑘)

𝑎𝑘,𝑘

(𝑘)

For columns 𝑗 = 𝑘 to 𝑛 − 1

𝑎𝑖,𝑗

(𝑘+1) = 𝑎𝑖,𝑗

(𝑘) − 𝑚𝑎𝑘,𝑗

(𝑘)

Next 𝑗

𝑏𝑖

(𝑘+1) = 𝑏𝑖

(𝑘) − 𝑚𝑏𝑘

(𝑘)

Next 𝑖

Next 𝑘

After this procedure the matrix equation takes the form

[

𝑎0,0

(0) 𝑎0,1

(0) 𝑎0,2

(0) ⋯ 𝑎0,𝑛−1

(0)

0 𝑎1,1

(1) 𝑎1,2

(1) ⋯ 𝑎1,𝑛−1

(1)

0 0 𝑎2,2

(2) ⋯ 𝑎2,𝑛−1

(2)

⋮ ⋮ ⋮ ⋱ ⋮

0 0 0 ⋯ 𝑎𝑛−1,𝑛−1

(𝑛−1) ] [

𝑥0

(0)

𝑥1

(0)

𝑥2

(0)

⋮

𝑥𝑛−1

(0) ]

=

[

𝑏0

(0)

𝑏1

(1)

𝑏2

(2)

⋮

𝑏𝑛−1

(𝑛−1)]

The unknowns 𝑥𝑘 may be found by first finding the nth unknown

𝑥𝑛−1 = 𝑏𝑛−1

𝑎𝑛−1,𝑛−1

The remainder may be found by the formula (again in pseudo-code):

For 𝑘 = 𝑛 − 2 to 0 step −1

𝑥𝑘 = 1

𝑎𝑘,𝑘

[𝑏𝑘 − ∑ 𝑎𝑘,𝑗

𝑛−1

𝑗=𝑘+1

𝑥𝑗]

Next 𝑘3

To test your program, you may use the set of equations

−1𝑥0 + 2𝑥1 + 1𝑥2 = 0

−2𝑥0 + 2𝑥1 + 3𝑥2 = 3

−1𝑥0 − 3𝑥1 + 0𝑥2 = 2

which have the solution 𝑥0 = 1, 𝑥1 = −1, and 𝑥2 = 1.

Write the program to allow the user to input the number of equations in the set and allow

the user to input all the coefficients. Test the program using the set of 3 equations shown

above and the sets of equations shown below.

Set of 4 equations:

−2𝑥0 + 01𝑥1 − 1𝑥2 + 2𝑥3 = 5

−4𝑥0 + 05𝑥1 − 3𝑥2 + 6𝑥3 = 9

−2𝑥0 + 05𝑥1 − 2𝑥2 + 6𝑥3 = 4

−4𝑥0 + 11𝑥1 − 4𝑥2 + 8𝑥3 = 2

Set of 5 equations

2𝑥0 − 2𝑥1 + 2𝑥2 − 2𝑥3 + 2𝑥4 = 6

2𝑥0 + 0𝑥1 + 0𝑥2 + 0𝑥3 + 0𝑥4 = 2

2𝑥0 + 0𝑥1 + 2𝑥2 − 2𝑥3 + 2𝑥4 = 6

2𝑥0 + 0𝑥1 + 2𝑥2 + 0𝑥3 + 0𝑥4 = 0

2𝑥0 + 0𝑥1 + 2𝑥2 + 0𝑥3 + 2𝑥4 = 6

Document your program with the following:

A. A written description of the purpose of the program and the structure of the

programming.

The purpose of this program is to solve a gaussian elimination problem of any size. It uses

arrays, a while loop, several for loops, and several pointers to solve this problem.

B. A flowchart to graphically display the structure of the program.

A diagram of a program

Description automatically generated

A screenshot of a computer program

Description automatically generated

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