

Mini project on “Scientific Calculator”

Objectives

1. To be familiar with C programming language.
2. To implement various mathematical operations in C language.
3. To build a simple project on C.

Overview

The project will be a simple Scientific Calculator implementation in C. You will use various calculations to calculate different mathematical operations. The output of the project will be a console application without any graphics. You should implement at least following mathematical operations.

1. 2D Matrix operations like Addition, Subtraction, Multiplication, Transpose (Determination and Inverse are optional, you will learn more advance techniques in Numerical Method in 5th semester)
2. Solution of non-linear polynomial equations [2nd order only, 3rd order is optional]
3. Calculation of Sine, Cosine, Tangent of a given angle in degree.
4. Solution of simultaneous algebraic equations [2 and 3 variables only].
5. Complex number operations like, addition, subtraction, multiplication of two complex numbers, magnitude of a complex number

You will implement above 6 mathematical operations in C. This may appears difficult to you at first, but these are very simple operations and it will become simpler as you progress. To make the above points more clear, let’s discuss them in detail.

Detail Explanation

I will give you all the steps you will need to complete the project. I assume that you have all the mathematical knowledge about above operations. I just show you how to implement them in program. Let’s go step by step

1. 2D Matrix operations like Addition, Subtraction, Multiplication, Transpose (Determination and Inverse are optional, you will learn more advance techniques in Numerical Method in 5th semester)

Solution:

You know the basic 2 Dimensional matrix operations from your math class. A two dimensional matrix is in the form

$$A = \begin{matrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{matrix}$$

It has rows and columns. The above matrix has 3x3 dimensions meaning 3 rows and 3 columns. Above matrix can be represented in C program by using two dimensional array as

```
float A[3][3];
```

This allocates a memory of total 9 variables having 3 rows and 3 columns. Here A[3][3] is the matrix representation of above matrix A in C program. Each element of the matrix can be accessed by using index, for example the first element a_{11} is equal to A[1][1] similarly the last element a_{33} is equal to A[3][3]. A simple C program for declaring matrix and getting the elements from user is given below, look carefully the code

```
float A[3][3]; // declaration of 3x3 matrix A
int i, j;
for(i = 0; i < 3; i++){
    for(j = 0; j < 3; j++){
        scanf("%f", &A[i][j]);
    }
}
```

Addition, Subtraction of Matrix

Matrix addition is element wise addition process. Each element is added to the corresponding element of another matrix. For example, a_{11} of A is added with b_{11} of B, a_{12} of A is added with b_{12} of B and so on. A C code of implementing addition operation is given below.

```
float A[3][3], B[3][3], C[3][3];
// get matrices A, and B from user, sum them and store the
result in matrix C
// you can get the matrices A and B from user using above
procedure.
int i, j;
for (i = 0; i < 3; i++){
    for (j = 0; j < 3; j++){
        C[i][j] = A[i][j] + B[i][j];
    }
}
```

Similarly you can calculate Multiplication and transpose of matrix.

2. Solution of non-linear polynomial equations [2nd and 3rd order only]

Solution:

We can write the 2nd order polynomial equation in the form of

$$ax^2 + bx + c$$

For the given value of a, b and c [which you get from user], you will solve the above quadratic equation and calculate the roots. Note: The 2nd order equation will have at most 2 roots. The roots can be calculated by following formula.

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Similarly the 3rd order polynomial (Cubic equation) can be written as

$$ax^3 + bx^2 + cx + d$$

For the given value of a, b, c and d you will solve the above equation and calculate the roots. A cubic equation can have upto 3 roots. 1 real roots and 1 complex conjugate or 3 real roots. There is no any formula to calculate the roots of 3rd or higher order polynomial equations, however, you can use some difficult numerical methods techniques like Bisection method, Secant Method, Newton Raphson method etc. In C program, you must calculate the roots (real or imaginary) of quadratic equations using above formula. To prevent the possible error, you must first check the determinant term $b^2 - 4ac$, if it is negative then the root will be complex conjugate otherwise you will get real roots. The algorithm is given below

Step1: Get the coefficients a, b, c from the user

Step2: Calculate $term = b^2 - 4ac$.

Step3: If it is negative, goto step 4 and 5 otherwise goto step 6

Step4: Since your C program cannot calculate the square root of -ve number, first you take absolute value of term, and then take the square root.

$$\text{sqrtTerm} = \text{Sqrt}(\text{abs}(\text{term}))$$

Step5: Display the root as $\frac{-b \pm \text{sqrtTerm} i}{2*a}$

Step6: Calculate the root using above formula and display the root

3. Calculation of Sine, Cosine, Tangent of a given angle in degree.

Solution:

In this exercise, you are not allowed to the built in function of math.h : sin, cos and tan, rather you have to write you own functions using Taylor Series (Specifically Maclurin series). The formula for calculating sine is, for example,

$$\sin(x) = \frac{x}{1} - \frac{x^3}{3!} + \frac{x^5}{5!} - \dots \text{to } \infty$$

In C program you may iterate through 100 times or more only. Other important thing is you get the angle in degree but to calculate the series, you must supply the value in radian. For this convert the value from degree to radian first. Similarly you can calculate the cos and tan.

4. Solution of simultaneous algebraic equations [2 and 3 variables only].

Solution:

For example you are given two equations

$$y = 3x + 5 \text{ and } y = 2x - 8$$

and you are asked to calculate the value of x and y that satisfies the given two equations. This type of problems are called simultaneous algebraic equations. You must calculate the solution of 2 and 3 variables only but your program may be more general that can calculate the solution of any number of variables. To solve this type of problem, you have various methods like Row Equivalent (Gauss Jordan), Gauss Elimination and so on. Search about the methods, know them and implement them in the program.

Programming hint:

Gauss Jordan and Gauss Elimination method are calculated first creating an augmented matrix as follows:

$$\begin{array}{ccc|c} 3 & 5 & : & 1 \\ 2 & -8 & : & 1 \end{array}$$

This is the augmented matrix for the equations given above. You can get some knowledge about how to implement them in program by closely looking at the augmented matrix. For the two variables the dimension of augmented matrix is 2x3 and for 3 variables it will be 3x4 and so on.

5. Complex number operations like, addition, subtraction, multiplication of two complex numbers, magnitude of a complex number

Solution

You can see the various books to get the idea about complex number operations. I only show you how to implement them in program. Since complex numbers have two components real and imaginary, you should make use of structure construct in C to represent the complex number. For example

```
struct Complex{
    float real;
    float imag;
};
struct Complex c1, c2, c3;
// you can add the two complex number using
c3.real = c1.real + c2.real
c3.imag = c1.imag + c2.imag
Similarly you can carry out other operations.
```

Prepared by Bibek Subedi, IOE

To make you easier to step through the project, a sample C file is attached with this document that guides you how to setup the project. See the attached file for more detail