Project Report On

MATHOLOGY

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As a summer project of 2nd year vacations

“To estimate a project, work out how long it would take one person to do it then multiply that by the number of people on the project”.

“The first 90% of our project took 90% of the time and the last 10% took another 90%”.

Abstract

This project was undertaken in Computer Engineering department, Fr.C.R.I.T Navi Mumbai during the year 2008-2009.
This report gives the details about the project which we have completed during the second year vacation of our engineering course.

Chapter wise abstract is furnished here under,

- Chapter 2 describes the various features of calculus which includes differentiation, numerical differentiation and numerical integration.
- Chapter 3 describes the various features of matrices which include addition, subtraction, inverse and various other highlights.
- Chapter 4 describes various features of expression evaluator which would help the user to evaluate various expressions accurately.
- Chapter 5 describes solving of n simultaneous equations which would take a long time if done otherwise.
- Chapter 6 describes finding roots of any non linear equation which has got many applications in many fields.

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Chapter 1

INTRODUCTION

Introduction

Mathematics is one of the oldest fields of science and lots of applications have been developed to simplify the human work in calculations. The aim of our project is to develop a user friendly and interesting way to solve the advanced mathematics problems.

The user thus gets the answers to most of his queries using only basic inputs.

1.1 Objectives:-

The main aim of the project is develop entire mathematical library in the form of simple user friendly and platform way. All the library codes are made in such a way that they can be imported in a currently developing project and can be used to perform any desired mathematical operations with higher accuracy. Also, other mathematical functionality can be integrated into the code with easily with existing tools.

1.2 Scope:-

Software will provide various icons guiding through the operation which the user needs to perform.

The operations that are supported are:

1. Expression Evaluator
2. Calculus
    - 2a.Numerical Integration
    - 2b.Numerical Differentiation
    - 2c.Differentiation
3. Matrices
4. Simultaneous Equation Solver
5. Single variable non linear equation solver

1.3 Selection of Programming languages:-

In order to develop this software standard java (jdk 1.6.0) is used.

Also net beans 6.5.1 is used for GUI development.

Chapter 2

Calculus

Calculus

More generally, *calculus* (plural *calculi*) refers to any method or system of calculation guided by the symbolic manipulation of expressions. It basically focuses on *limits, derivatives, integrals and infinite series*. Calculus focuses on study of a change of one factor and its effect on other factor. Hence, in various branch of science where one factor depends on the other, calculus is used to study the behaviour of all the factors. Calculus in used in every branch of physics, computer science, statistics, engineering, economics, business, medicine, demography and in other fields wherever a problem can be modelled mathematically and an optimal solution among all possible solution is required.

As a part of our project we have implemented both *Integral calculus* as well as *Differential calculus.* All the calculus expressions supported are:

1. Basic Arithmetic Expression
2. Trigonometric Expression
3. Inverse Trigonometric Expression
4. Logarithmic Expression
5. Exponential Expression

And all the possible expressions, which can be created by nesting above 6 types of expressions.

Integral Calculus

Integration is an important concept in mathematics, together with differentiation, forms one of the main operations in calculus. Given a function f of a real variable x and an interval $[a, b]$ of the real line, the definite integral

$$\int_a^b f(x)\,dx\,,$$

is defined informally to be the net signed area of the region in the xy-plane bounded by the graph of f, the x-axis, and the vertical lines $x = a$ and $x = b$.

Various algorithms are available to calculate definite integral of a function. We have used Newton-Cotes 11 point formula, because of its accuracy and relatively less calculations needed. The formula is:

$$\int_{x_1}^{x_{11}} f(x)\,dx = \frac{5}{299\,376}\,h\,[16\,067\,(f_1 + f_{11}) + 106\,300\,(f_2 + f_{10}) - 48\,525\,(f_3 + f_9) + 272\,400\,(f_4 + f_8)$$

$$- 260\,550\,(f_5 + f_7) + 427\,368\,f_6] - \frac{1\,346\,350}{326\,918\,592}\,h^{13}\,f^{(12)}(\xi)$$

Where $h = (x_2 - x_1)/11$. And the error term is:

$$\frac{1\,346\,350}{326\,918\,592}\,h^{13}\,f^{(12)}(\xi)$$

This is very less compare to other values. Hence error caused is very less. And can be avoided.

Differential Calculus

Differential calculus, a field in mathematics, is the study of how functions change when their inputs change. The derivative of a function at a chosen input value describes the behavior of the function near that input value. For a real-valued function of a single real variable, the derivative at a point equals the slope of the tangent line to the graph of the function at that point. In general, the derivative of a function at a point determines the best linear approximation to the function at that point.

Differentiation has useful application in physics. *Motion* and all the motion related properties of bodies can be calculated by using differentiation. The reaction rate of a *chemical reaction* is a derivative. In *operations research*, derivatives determine the most efficient ways to transport materials and design factories. By applying *game theory*, differentiation can provide best strategies for competing corporations. Derivatives are frequently used to find the maxima and minima of a function and hence are used in *optimization related problems*. Derivatives and their generalizations appear in many fields of mathematics, such as *complex analysis, functional analysis, differential geometry, measure theory and abstract algebra.* In *finite elemental analysis*, differentiation is very useful.

As a part of our project, we have implemented both numerical and general differentiation.

For General Differentiation, we have implemented our own algorithm which works on recursive principle. And divides the given expression recursively into sub-expressions differentiates them and finally combines them to produce the differentiation of original expression.

For Numerical Differentiation, the differentiation of the expression is evaluated at a particular user defines value. It works only for real value of range the expression and does not process for complex value.

Chapter 3

Matrices

Matrices

This is a very vast branch of mathematics. Matrices help us solve lengthy or/and difficult problems in a very easy way. This has made the applications of matrices to expand rapidly so much that it’s time to think to develop software now helping us solve these matrices. Because of the ease it brings to solving problems not many software applications are developed to help solving them.

Some of the many functions related to matrices include in the software are:

1. Arithmetic
    - Addition
    - Subtraction
    - Multiplication
2. Singular functions
    - Determinant
    - Trace
    - Inverse
    - Transpose

Chapter 4

Expression Evaluator

Expression Evaluator

With the advance in technology, it became advent for the users to use devices which would not only make their calculations faster but also flawless.

Thus we made an expression evaluator which can evaluate all sorts of expressions.

The operators that can be included in the expression are:

1. Add, Subtraction, Multiply, Divide
2. Logarithm
3. Exponent
4. Sin, Cos, Tan
5. ASin, ACos, ATan
6. Power

All the operators work in the normal flow except for calculating the sine or the cosine or the tan values of the angles, we have to convert the angle in degree otherwise the expression takes it in the radian form.

To evaluate any expression the expression is initially converted into postfix form then using stack the expression is evaluated. No precision is considered. Hence, to evaluate an expression using braces precision can be changed or assigned.

Chapter 5

Single variable non linear equation solver

Single Variable Non-linear Equation Solver

A single variable non linear equation solver is an application of mathematics which will provide the user with all the roots of any non linear single variable equation.

This application takes the expression from the user as the input and check if there are any errors as per the entered expression on compilation of the code.

If there are any errors then the user will be given suitable error message and thus can then go back and correct them accordingly.

The user is required to give the initial values to the expression and thus the user gets the roots accordingly. For the implementation of the code, Newton-Raphson's method was used and it is given by:

Newton-Raphson:

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$$

The derivative of the expression was taken by the derivative class.

Drawbacks:

Here the factor of convergence is 1.692 and if the initial value is not near to the exact root then convergence may take long time.

Chapter 6:

Simultaneous Equation Solver

Simultaneous Equation Solver

In mathematics, simultaneous equations are a set of equations containing multiple variables. This set is often referred to as a system of equations. A solution to a system of equations is a particular specification of the values of all variables that simultaneously satisfies all of the equations. Each equation in a system of equations must be linear in terms of all the variables.

Generally, simultaneous equations are used in mechanics for truss analysis purpose. In network related problems or tree evaluation, simultaneous equations have been found useful.

Various standard algorithms are available to solve simultaneous equations.

1. Trial and error method
2. Substitution method is used to solve system of non linear equations
3. Gauss Elimination Method
4. Matrix Method
5. Least squares Method

For our implementation purpose we have used **Matrix Method** to solve simultaneous equations. Here Necessary and sufficient condition is that

1. For given N unknowns in the equation at least N equations should be present.
2. All the N equations should be independent of each other.

The systems of equations are represented by:

$$AX = B$$

Where A = coefficient of unknowns

B = the constant term.

Then the solution of system is:

X = Inverse(A) * B

This operation is performed at the matrix level.

The software is made to work with only maximum 10 unknown variables. But practically, it can work for all positive integer value of N. The limitation of the system is that all the coefficient values must be real double values. Otherwise the solution won’t work at all.

Conclusion

We have implemented coding of various applications of mathematics and using Java.

It has been observed that doing manual calculations like differentiation ,integration , solving matrices ,finding roots of higher degree equations and solving n simultaneous degree equations is not only tedious and consumes large amount of time but also may not give accurate results many times.

Thus we developed this software to give accurate and precise solutions to major queries of the user. The application is user friendly and gives appropriate errors on compilation and thus guides the user if he is off track.

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