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Analysis of Interpolation by using Lagrange's Method

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Abstract: In many applications that use tabulated data it is necessary to evaluate the value of a function for a value of the independent variables that is not one of the tabulated values. It need to use interpolation to evaluate the function at the desired value of the independent variables. Interpolated value is generally an approximation to the actual value of the function that is represented by the tabulated data. Interpolating function is used within the range of the tabulated values in constructing the approximating function.

I. INTRODUCTION

Introducing interpolation that means to find the function of f(x) which passes through a given set of points, [3]
Consider the data, x and f(x) table shows the below,

Table 1.1

X	Y=f(x)
1	16
2	29
3	43
4	61

By looking at this table we cannot directly find the value of Y=f(x) at x=2.5
But if we know that the polynomial which passes through all these point (1,16), (2,29), (3, 43) & (4, 61); then we can easily determined the value of Y at x=2.5. Approximate curve passing through all these points can be obtained graphically shows in the fig (1) below.

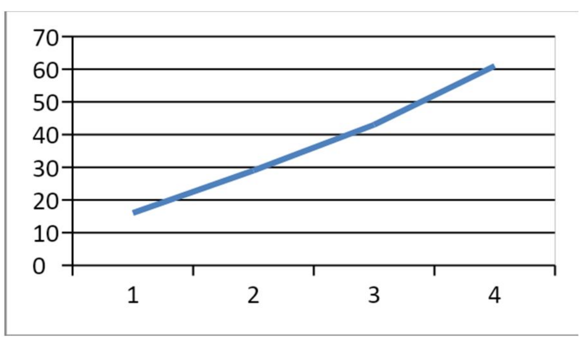

Fig: - 1.1 Data Graphical Representation

The approximate curve of f(x) obtained by graphical interpolation through all the points is shown in fig (1).
There are some methods in the interpolation due to find the values of table data in the simple form, [4]
Polynomial interpolation methods:-

1) Lagrange's Method.
2) Newton's Forward Method.
3) Newton's Backward Method.
4) Centre Difference Method. Now,

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We find the first method of lag ranges interpolation.
This method is more beneficial as it does not require any differences. It can be applied to any type of data irrespective of the spacing for the values of x.

A. Derivation

1) *Example:* For the following data find the value of y at x=4 using Lagrange's interpolation method. [2]

Table: - 1.2

X	1	2	3	5
Y	0	7	26	124

Solution

$Yr = (Xr-X_1) (Xr-X_2) (Xr-X_3) /$

$(X_0-X_1) (X_0- X_2) (X_0-X_3) Y_0 +$

$(Xr-X_0) (Xr-X_2)(Xr-X_3) /$

Consider three data points (XY),
$(X_1-X_0) (X_1-X_2) (X_1-X_3) Y_1 +$

0, 0

(X Y),(X Y) which Are an evenly

$(Xr-X_0) (Xr-X_1) (Xr-X_3) /$

1, 1 2, 2

space. [2]
Consider the second order polynomial
$y=b_1(x_0-x_1)(x_0-x_2) + b_2(x_1-x_0)(x_2-x_2) + b_3(x_2-x_0)(x_2-x_1)$

Since the three points to be interpolating, $(X_0, Y_0), (X_1,Y_1),(X_2,Y_2)$

Therefore we can write,

$Y_0= b_1(x_0-x_1)(x_0-x_2)$

$Y_1= b_2(x_1-x_0)(x_1-x_2)$

$Y_2=b_3(x_2-x_0)(x_2- x_1)$

So,

$b_1= Y_0 / (X_0-X_1) (X_0-X_2)$ b =Y / (X -X) (X -X)

$(X_2-X_0) (X_2-X_1) (X_2-X_3) Y_2 +$

$(Xr-X_0) (Xr-X_1) (Xr-X_3) /$

$(X_3-X_0) (X_3-X_1) (X_3-X_3) Y_3$

Yr = (4-1)(4-2)(4-5)/(1-2)(1-3)(1-5)*(0) +
(4-1)(4-3)(4-5)/(2-1)(2-3)(2-5)*(7) +
(4-1)(4-2)(4-5)/(3-1)(3-2)(3-5)*(26)+
(4-1)(4-2)(4-3)/(5-1)(5-2)(5-3)*(124)+

= -7+39+31

Y_r =63 ------- <u>Ans</u>

2) *Example 2:* For the following data find

$\sqrt{1.1}$ using Lagrange's interpolation & determined the accuracy. [1]

2 1 1 0 1 2

X =1.1

r

b =Y / (X -X) (X -X)

2 2 2 0 2 1

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Table:- 1.3

X	1	1.2	1.3	1.4
$\sqrt{X}$	1	1.095	1.140	1.163

Substitute the value of b_1, b_2, b_2 in Equation (1)

We get,

$Y = (X-X_1)(X-X_2)/(X_0-X_1)(X_0-X_2)\,Y_0$

$+ (X-X_0)(X-X_2)/(X_1-X_0)(X_1-X_2)\,Y_1$

$+ (X-X_0)(X-X_1)/(X_2-X_0)(X_2-X_1)\,Y_2$

For general formula substitute Y=Yr at X=Xr.

$$\boxed{\begin{aligned} Yr = {} & (Xr-X_1)(Xr-X_2)/(X_0-X_1)(X_0-X_2) \\ & {}^*Y_0 + (Xr-X_0)(Xr-X_2)/(X_1-X_0) \\ & (X_1-X_2)Y_1 + (Xr-X_0)(Xr-X_1)/ \\ & (X_2-X_0)(X_2-X_1)Y_2 \end{aligned}}$$

Solution

$Yr = (Xr-X_1)(Xr-X_2)(Xr-X_3)/$

$(X_0-X_1)(X_0-X_2)(X_0-X_3)\,Y_0 +$

$(Xr-X_0)(Xr-X_2)(Xr-X_3)/$

$(X_1-X_0)(X_1-X_2)(X_1-X_3)\,Y_1 +$

$(Xr-X_0)(Xr-X_1)(Xr-X_3)/$

$(X_2-X_0)(X_2-X_1)(X_2-X_3)\,Y_2 +$

$(Xr-X_0)(Xr-X_1)(Xr-X_3)/$

(X -X) (X -X) (X -X) Y

$Y_0 = 1$

3 0 3 1

3 3 3

$Y_0 = 1.095$

$Y_0 = 1.140$

Yr= (1.1-1.2)(1.1-1.3)(1.1-1.4) /
(1-1.2)(1-1.3)(1-1.4) * (1) +
(1.1-1)(1.1-1.3)(1.1-1.4) /
(1.2-1)(1.2-1.3)(1.2-1.4) * (1.095) +
(1.1-1)(1.1-1.2)(1.1-1.4) /
(1.3-1)(1.3-1.2)(1.3-1.4) * (1.140) +
(1.1-1)(1.1-1.2)(1.1-1.4) /
(1.4-1)(1.4-1.2)(1.4-1.4) * (1.163)

Y_r = 0.25+1.642-1.14+0.436 Y_r =1.0483 ------------- Ans.

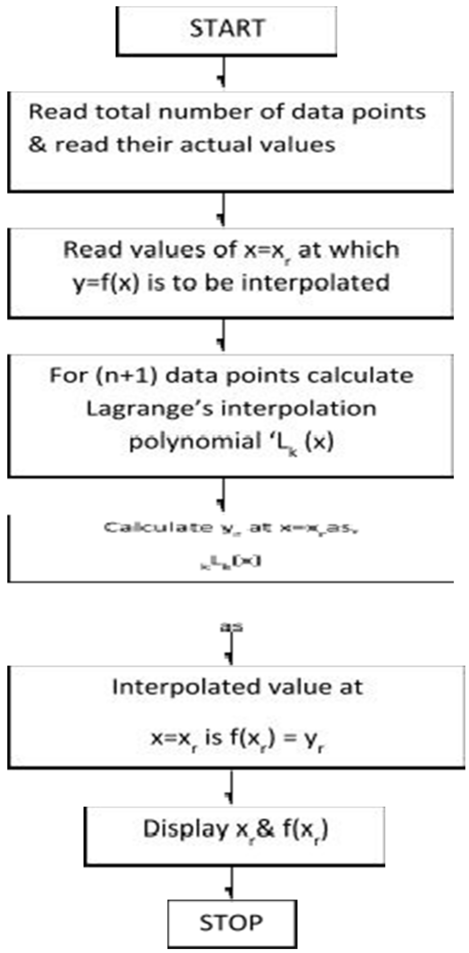
Actual value of $\sqrt{1.1}$ is 1.0488

$Y_0 = 1.183$

Enter the value of x_r at which y = f(x)
is to be interpolated, x_r = 1.1

The value of y = f(x) at x_r = 1.100000 is y_r = 1.048250.

Flow Chart



Therefore,
Error in interpolation=1.0488-1.0483
= 0.0005

B. Program

A 'C ' program for Lagrange's interpolation is shown below. [6]

/*---------Lagrange's Interpolation Method-------*/
/* The Program Calculation The Value Of F(X) At Given Value Of X Using Lagrange's Interpolation Method.

1) Input

a) Number of entries of the data.
b) Values of 'x' & corresponding y =f(x)
c) Values of 'x_r' at which y = f(x) to be calculated.

2) Outputs: Interpolated values f(x) at x = x_r.

II. RESULT

[5] Enter the number of entries (max 20) = 4 X_0 = 1
X_1 = 1.2
X_2 = 1.3
X_3 = 1.4

III. CONCLUSION

The Formula is described by equation can be used to represent a given set of numerical data on a pair of variables, by a polynomial. The degree of the polynomial is one less than the number of pairs of observation.

The polynomial that represents the given set of numerical data can be used for interpolation at any position of the independent variable lying within its two extreme values.

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