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Lagrange's Interpolation

What is Interpolation?

Interpolation is a method of finding new data points within the range of a discrete set of known data points (Source [Wiki](#)). In other words interpolation is the technique to estimate the value of a mathematical function, for any intermediate value of the independent variable.

For example, in the given table we're given 4 set of discrete data points, for an unknown function $f(x)$:

i	1	2	3	4
x_i	0	1	2	5
$y_i = f_i(x)$	2	3	12	147

How to find?

Here we can apply the Lagrange's interpolation formula to get our solution.

The Lagrange's Interpolation formula:

If, $y = f(x)$ takes the values y_0, y_1, \dots, y_n corresponding to $x = x_0, x_1, \dots, x_n$ then,

$$f(x) = \frac{(x-x_2)(x-x_3)\dots(x-x_n)}{(x_1-x_2)(x_1-x_3)\dots(x_1-x_n)}y_1 + \frac{(x-x_1)(x-x_3)\dots(x-x_n)}{(x_2-x_1)(x_2-x_3)\dots(x_2-x_n)}y_2 + \dots + \frac{(x-x_1)(x-x_2)\dots(x-x_{n-1})}{(x_n-x_1)(x_n-x_2)\dots(x_n-x_{n-1})}y_n.$$

This method is preferred over its counterparts like Newton's method because it is applicable even for unequally spaced values of x .

We can use interpolation techniques to find an intermediate data point say at $x = 3$.

```
// C++ program for implementation of Lagrange's Interpolation
#include<bits/stdc++.h>
using namespace std;

// To represent a data point corresponding to x and y = f(x)
struct Data
{
    int x, y;
};

// function to interpolate the given data points using Lagrange's formula
// xi corresponds to the new data point whose value is to be obtained
// n represents the number of known data points
double interpolate(Data f[], int xi, int n)
{
    double result = 0; // Initialize result

    for (int i=0; i<n; i++)
```



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```
// Add current term to result
result += term;
}

return result;
}

// driver function to check the program
int main()
{
    // creating an array of 4 known data points
    Data f[] = {{0,2}, {1,3}, {2,12}, {5,147}};

    // Using the interpolate function to obtain a data point
    // corresponding to x=3
    cout << "Value of f(3) is : " << interpolate(f, 3, 5);

    return 0;
}
```

[Run on IDE](#)

Output:

Value of f(3) is : 35

Complexity:

The time complexity of the above solution is $O(n^2)$ and auxiliary space is $O(1)$.

References:

https://en.wikipedia.org/wiki/Lagrange_polynomial

Higher Engineering Mathematics , Dr. B.S. Grewal

https://mat.iitm.ac.in/home/sryedida/public_html/caimna/interpolation/lagrange.html

This article is contributed by [Ashutosh Kumar](#). Please write comments if you find anything incorrect, or you want to share more information about the topic discussed above



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