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THE NUMERICAL INTEGRATION IN MATHCAD

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Annotation

This article discusses the integration of a discrete function using spline approximation. Considered in a specific example and applied to the calculation of the software product MathCAD.

Keywords: approximation, spline, discrete, integral, numerical – analytical.

Introduction

When solving practical problems, functions are specified discretely [1-9]. In these cases, the integrand must be approximated on the interval [a,b] i.e. $f(x) \approx g(x)$, $g(x)$ – the approximated function. Then we have:

$$\int_a^b f(x)dx \approx \int_a^b g(x)dx$$

$\int_a^b g(x)dx$ - can be calculated numerically or numerically - analytically. Usually the segment [a,b] is divided into n parts, the integral will be equal to the sum of the integrals

$$\int_a^b \mathrm{g}(x)dx \approx \sum_{i=0}^{n-1} \int_{x_i}^{x_{i+1}} g(x)dx$$

Let's consider elementary methods of integration - analytical-numerical methods [10-24].

Linear interpolation

We approximate the integrand. Consider $\{a = x_0 < x_1 < x_2 < ... < x_n = b\}$ a grid and approximate a discrete function with a first-order spline [25-37]:

$$S_1(x) = f(x_i) + A_i(x - x_i), \qquad x \in [x_{i+1}, x_i], \ i = 0, n-1$$

where $A_i = \frac{f(x_{i+1}) + f(x_i)}{h}$, $h = \max_i h_i$ $h -$ step

Then $I = \sum_{i=0}^{n-1} \int_{x_i}^{x_{i+1}} S_1(x)dx$. It can be proved that the estimate for the error is valid

$$|f(x) - S_1(x)| \le \frac{h}{2} \max_{x \in [a,b]} |f'(x)|$$

Task 1. Consider an example where the function value is given in a table:

x	-1	-0.5	0	0.5	1
$f(x)$	0.135	0.368	1	2.7	7.389

For numerical integration, we approximate the table function given by a first-order spline on the interval $[x_{i-1}, x_i]$

$$s1 := \int_{-1}^{-0.5} 0.135 + 1.268(x+1)\,dx \rightarrow 0.226$$

$$s2 := \int_{-0.5}^{1} [0.368 + 3.42(x+0.5)]\,dx \rightarrow 4.3995$$

$$s3 := \int_{0}^{0.5} [1 + 12.612(x-0)]\,dx \rightarrow 2.0765$$

$$s4 := \int_{0.5}^{1} [2.7 + 5.045\cdot(x-1)]\,dx \rightarrow 0.719375$$

So the integral X_2

$$i11 := \int_{-1}^{1} e^{2\cdot x}\,dx \rightarrow \frac{e^{2}}{2} - \frac{e^{-2}}{2}$$

or $\int_{-1}^{1} e^{2x}dx = 7.221$

where e^{2x} interpolated function.

Task 2.Calculate the integral given in the table

x	-1	-0.5	0	0.5	1
y	0.25	0.5	1	2	4

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To integrate this function, we use the MathCAD software product [38-51].

In MathCAD there are "built-in" functions for numerical-analytical integration, we will use a cubic spline - cspline. To integrate discrete data, we will approximate with a cubic slline. To do this, we create a matrix

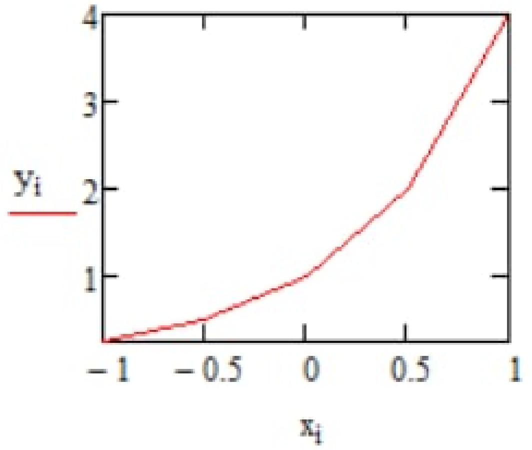
$$x := \begin{pmatrix} -1 \\ -0.5 \\ 0 \\ 0.5 \\ 1 \end{pmatrix} \qquad y := \begin{pmatrix} 0.25 \\ 0.5 \\ 1 \\ 2 \\ 4 \end{pmatrix}$$

$$n := 4 \qquad i := 0..4 \qquad h := 0.5$$

$$t_i := i \cdot h \qquad s := \mathrm{cspline}(t, y)$$

$$I1 := \int_{-1}^{1} \mathrm{interp}(s, t, y, x)\, dx$$

$$I1 = 0.583$$



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