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Loss of Specialization in Real Integrals with Multiplicative Method

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Abstract: In such cases it is necessary to construct exact quadratic formulas, as there are some errors in the approximate calculation of specific or non-specific integrals whose first-order derivatives become infinity in a given interval. In this work, the multiplicative method of loss of specificity under the integral of integral or non-specific integrals in which the first-order derivatives become infinity in a given interval is considered.

Keywords: multiplicative, orthogonal, specific, non-specific, integral, piecemeal, polinom

The problem of approximate integrals derived from a function with a finite number of products in the integration interval is well described in the mathematical literature. It is not possible to approximate the integral or non-specific integrals, one of the first derivatives of which is infinity, because it can give gross errors. Therefore, it is necessary to construct as accurate quadratic formulas as possible for such integrals. One such method is the multiplicative method, which allows you to get rid of the special under the integral.

Here is the essence of the multiplicative method.

Suppose, in the integration interval

$$\int_a^b \varphi(x)dx \qquad (1)$$

Let the $\varphi(x)$ function under the integral have some speciality. Suppose a function

$$\varphi(x) = \omega(x) f(x)$$

be able to write in the form, where $\omega(x)$is a positive function that contains all of the given properties, and $f(x)$ is a (smooth) function with no special properties and 2n is an ordered product [2]. Using this, we can use Gauss's formula for the above integral (1) [3]:

$$\int_a^b \omega(x) f(x)dx = \sum_{k=1}^{n} A_k^{(n)} f\left(x_k^{(n)}\right). \qquad (2)$$

while its residual hadi

$$R_n(f) = \frac{f^{(2n)}(\xi)}{(2n)!}\int_a^b \omega(x)\tilde{\omega}_n^2(x)dx,$$

$$a \le \xi \le b$$

determined by the formula. Here, the function $\tilde{\omega}_n(x)$ is a polynomial of degree *n*, $x_k^{(n)}$is the root of $\tilde{\omega}_n(x)$, and $A_n^{(n)}$ is the coefficient of formula (2), which are:

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$$A_k^{(n)} = \frac{1}{\omega_n^1\left(x_k^{(n)}\right)} \int_a^b \omega(x) \frac{\omega_k(x)}{x - x_k^{(n)}} dx . \qquad (3)$$

The following properties are appropriate for these coefficients:

1. $\sum_{k=1}^{n} A_k^{(n)} = \int_a^b \omega(x) dx$.

2. All $A_k^{(n)}$ coefficients are positive.

Thus, for the calculation of nonlinear integrals in a multiplicative way, all the properties of the integral are loaded into a weighted function, the corresponding orthogonal polynomial is restored, their nodes $x_k^{(n)}$ are found, and $A_k^{(n)}$ are the coefficients[1].

Below we have a weighted function

$$\omega(x) = -\ln|x|, \qquad (-1 \le x \le +1)$$

We take the function and use the multiplicative method.

In section $[-1;\ 1]$, we construct polynomials $\tilde{\omega}_n(x)$, which are orthogonal to the weights $\omega(x) = -\ln|x|$, $(-1 \le x \le +1)$, and have the largest coefficients equal to one.

If we use the pair of the function $\omega(x) = -\ln|x|$ in $[-1;\ 1]$, the polynomials $\omega_n(x)$ we are looking at are at level x^k, so that the rank indicator comes with n only in pairs.

$\omega_n(x)$ polynomials from polynomial theory

$$\tilde{\omega}_{n+2}(x) = x\tilde{\omega}_{n+1}(x) - \lambda_{n+1}\tilde{\omega}_n(x) \qquad (4)$$

is found in the recurrent formula [1].

Of course, $\tilde{\omega}_0(x) = 1$, $\tilde{\omega}_1(x) = x$ become, $\tilde{\omega}_2(x) = x^2 - \lambda_1$ from (4)

Based on the property of orthogonality

$$\int_{-1}^{+1} \ln|x| \tilde{\omega}_2(x) dx = 0 \ \text{ yoki } \int_{-1}^{+1} \ln|x| \left(x^2 - \lambda_1\right) dx = 0$$

become, hence

$$\int_0^1 \ln x \left(x^2 - \lambda_1\right) dx = 0$$

Is derived. Let's split this integral down, $\lambda_1 = \frac{1}{9}$, and then we find the $\tilde{\omega}_2(x) = x^2 - \frac{1}{9}$ polynomial. That's the way we look at $\tilde{\omega}(x)$. (4) based

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$$\tilde{\omega}_3(x) = x\tilde{\omega}_2(x) - \lambda_2\tilde{\omega}_1(x) = x^3 - \left(\frac{1}{9} + \lambda_2\right)x.$$

From the condition of orthogonality

$$\int_{-1}^{+1} \ln|x|x\left[x^3 - \left(\frac{1}{9} + \lambda_2\right)x\right]dx = 0$$

from a pair of functions under the integral

$$\int_0^1 \ln x \cdot x\left[x^3 - \left(\frac{1}{9} + \lambda_3\right)x\right]dx = 0.$$

Let's break it down and integrate it,

$$\lambda_2 = \frac{9}{25} - \frac{1}{9} \text{ and, so, } \tilde{\omega}_3(x) = x^3 - \frac{9}{25}x.$$

That is, according to (4)

$$\tilde{\omega}_4(x) = x^4 - \left(\frac{9}{25} + \lambda_3\right)x^2 + \frac{1}{9}\lambda_3.$$

From the condition of orthogonality

$$\int_{-1}^{+1} \ln|x|x^2\tilde{\omega}_4(x)dx = 0,$$

$$\int_{-1}^{+1} \ln x \cdot x^2\tilde{\omega}_4(x)dx = 0,$$

$$\lambda_3 = \frac{23 \cdot 81}{25 \cdot 7^3}$$

we define. In this way, the appearance of $\tilde{\omega}_n(x)$ polynomials

$$\tilde{\omega}_0(x) = 1,\quad \tilde{\omega}_1(x) = x,\quad \tilde{\omega}_2(x) = x^2 - \frac{1}{9},$$

…

$$\tilde{\omega}_6(x) = x^6 - \frac{45 \cdot 11657}{121 \cdot 20347}x^4 + \frac{25 \cdot 2243}{11 \cdot 20347}x^2 - \frac{23 \cdot 25 \cdot 5689}{9 \cdot 49 \cdot 121 \cdot 20347}.$$

we define. Our next goal is to find the roots of the polynomials $\tilde{\omega}_n(x)$ found. To do this, using the Lobachevsky-Gref method, we find the roots of the polynomial $\tilde{\omega}_n(x)$. The coefficients of the constructed approximate formula are.

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$$A_k^{(n)} = \frac{1}{\omega_n^1\left(x_k^n\right)}\int_0^1 \ln|x| \frac{\omega_n(x)}{x - x_k^{(n)}}dx$$

found using formula [1].

Table 1.

n	$x_k^{(n)}$	$A_k^{(n)}$	$\log A_k^{(n)}$
1	0	2	0,3010300
2	$-1/3$	1	0
	$+1/3$	1	0
3	$-3/5$	$25/81 = 0{,}308642$	$\bar{1}{,}4894550$
	0	$112/81 = 1{,}382716$	0,1407330
	$+\frac{3}{5}$	$25/81 = 0{,}308642$	$\bar{1}{,}4894550$
4	-0,748296	0,135100	$\bar{1}{,}1303008$
	-0,224042	0,864900	$\bar{1}{,}9369658$
	0,221042	0,864900	$\bar{1}{,}9369658$
	0,629296	0,135100	$\bar{1}{,}1303008$
5	-0,809432	0,064942	$\bar{2}{,}8125257$
	-0,420490	0,387768	$\bar{1}{,}5885720$
	0,000000	1,094580	0,0392476
	0,420490	0,387768	$\bar{1}{,}5885720$
	0,809432	0,064942	$\bar{2}{,}8125257$

Based on the algorithm in the calculation, the calculation process of Table 1 was developed using high-level algorithmic languages (Delphi, Maple7), the roots of which are defined to 6 rooms.

Conclusion: Based on the above algorithm, the process of calculating specific or non-specific integrals whose first-order derivatives become infinity in a given interval by multiplication is carried out without loss of specificity under the integral.

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