Numerical Solutions of Volterra Integral Equations of the Second Kind using Lagrange interpolation via the Vandermonde matrix

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Abstract

A new method is established for solving Volterra integral equations of the second kind using Lagrange interpolation through the Vandermonde approach. The goal is to minimize the interpolation errors of the high-degree polynomials on equidistance interpolations by redefining the original Lagrange functions in terms of the monomial basis. Accordingly, the complexity of the calculations is significantly reduced, and time is saved. To achieve this, the given data and the unknown functions are interpolated using Lagrange polynomials of the same degree via the Vandermonde matrix. Moreover, the interpolant unknown function is substituted twice into both sides of the integral equation so that the solution is reduced to an equivalent matrix equation without any need to apply collocation points. The error norm estimation is proved to be equal to zero. It was found that the obtained Vandermonde numerical solutions were equal to the exact ones, the calculation time was remarkably reduced, the round-off error was significantly reduced and the problematics due to the high-degree interpolating polynomial was completely faded regardless of whether the given functions were analytical or not. Thus, interpolation via the Vandermonde matrix ensures the accuracy, efficiency and authenticity of the presented method.

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