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Improving Petrov-Galerkin elements via Chebyshev polynomials and solving Fredholm integral equation of the second kind by them. (English) Zbl 1410.65485


Summary: Two types of univariate Petrov-Galerkin elements using piecewise polynomials are described by Z. Chen and Y. Xu [SIAM J. Numer. Anal. 35, No. 1, 406–434 (1998; Zbl 0911.65143)] and four lemmas are proved for convergence of $k - 0$ Petrov-Galerkin elements. For $k - 0$ Petrov-Galerkin elements, the choice of $k$ has a restriction $1 \leq k \leq 5$. In this paper, we want to prove that some regular pairs exist which violate those lemmas and we are interested in showing how the continuous or discontinuous Petrov-Galerkin Lagrange-type $k - 0$ elements can be generalized to eliminate that restriction. For this purpose, we improve old constructions with using Chebyshev polynomials first kind and second kind. We will call these new elements the generalized continuous Lagrange-type $k - 0$ elements and the generalized discontinuous Lagrange-type $k - 0$ elements. After that, new proofs are introduced for four lemmas in [Chen and Xu, loc. cit.] by using the new constructions. The most important features of these improved regular pairs are the elimination of each restriction and having accuracy and efficiency of them in respect to common version. Finally, numerical results of some relevant counterexamples will demonstrate accuracy and efficiency of the suggested methods.

MSC:

65R20 Numerical methods for integral equations
45B05 Fredholm integral equations

Keywords:

Fredholm integral equations; Petrov-Galerkin elements; Petrov-Galerkin method; regular pairs; Chebyshev polynomials; generalized Petrov-Galerkin elements

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