§45 Development of Meshless Approach by Implicit Surface

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i) Introduction

In general, the region or the boundary must be divided into a set of elements before using the numerical code based on the finite element method (FEM) or the boundary element method (BEM). The elements are introduced not only for the approximation of the region shape but also for the definition of the interpolants. In other words, the method for representing the geometric shape is closely related to the basis functions in the FEM/BEM. However, it is this relation that complicates the input data for the FEM/BEM program.

The purpose of the present study is to develop the numerical method for solving the partial differential equation by completely separating the analytic definition of interpolants from the geometric elements. Especially, the aim of this year is to develop the new finite node methods (FNM) [1-2] and to resolve the accuracy degradation problem of the boundary node methods (BNM) [3].

ii) Novel Finite Node Methods

Although many types of FNM have been so far proposed, the EFGM [1] and the MLPGM [2] are widely applied to the numerical simulations. The differences between them are listed as follows: the target region of the weak form, the implementation method of the essential boundary conditions, and selections of the functional spaces including the test/trial functions. Thus, by changing the combination of the above 3 items, eight finite node methods can be obtained.

In the present study, the accuracy of eight methods is investigated numerically. The results of computations show that the Petrov-Galerkin method gives a highly accurate solution for the case where both the local weak form and Lagrange multipliers are adopted (see Fig. 1) [4].

iii) Accuracy Improvement of Boundary Node Methods

As is well known, the accuracy of the inner-point formula of the BEM/BNM is remarkably degraded in the vicinity of the boundary.

In the present study, it is found that the accuracy degradation is caused by the quasi-singular integrals. In order to resolve these difficulties, we have developed the higher-order regularization technique and have compared its accuracy with other methods. As a result, the accuracy degradation is considerably suppressed by means of the higher-order regularization. Moreover, it turns out that the double exponential (DE) formula is effective to the numerical evaluation of influence coefficients (see Fig. 2) [5].

References

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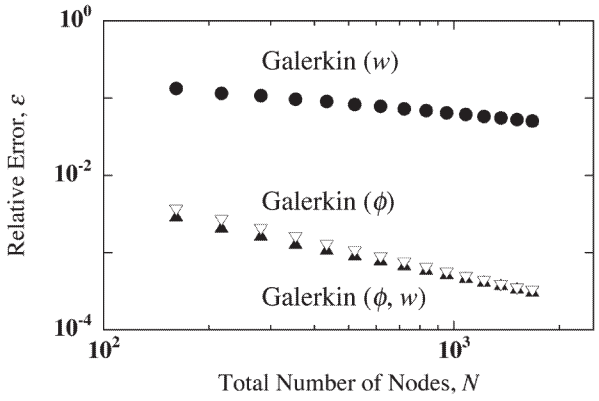

Fig. 1. Dependence of the relative errors on the total number of nodes for the cases where the local weak form and Lagrange multipliers are employed.

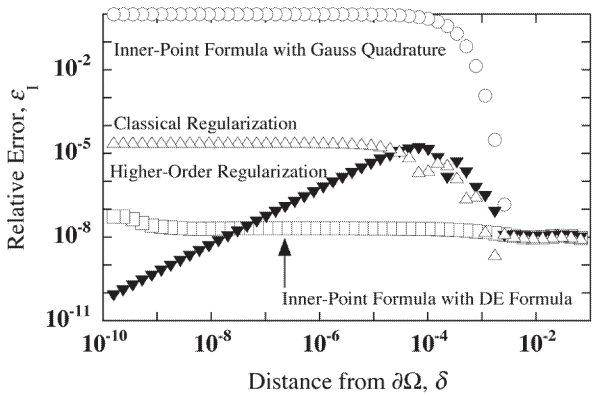

Fig. 2. Dependence of the relative errors on the distance from the boundary.