Title	Natural Element Method に適した並列アルゴリズムの開発
Author(s)	沼形，健児
Citation	
Issue Date	1997-03
Type	Thesis or Dissertation
Text version	author
URL	http://hdl.handle.net/10119/1045
Rights	
Description	Supervisor:松澤 照男，情報科学研究科，修士

Parallel Numerical Algorithm for Natural Element Method

Kenji Numagata

School of Information Science,
Japan Advanced Institute of Science and Technology

February 14, 1997

Keywords: Natural Element Method, Parallel computing, Domain decomposition.

There are two distinct alternative kinds of specification of flow field. The first ,usually called the Eulerian type, is like the specification of an electoromagnetic field in that the flow quantities are defined as function of position in space and time. The primary flow quantitiy is the velocity of the fluid. This Eulerian specification can be thought of as providing a picture of the spatial distribution of fluid velocity at each instant during the motion.

The second, called Lagrangian type of specification , makes use of the fact that , as in particle mechanics , some of the dynamical or physical quantities refer not only to certain positions in space but also to identifiable pieces of matter. The flow quantities are here defined as functions of time and of the choice of a material element of fluid, and describe the dynamical history of this selected fluid element.

Numerical methods for solving partial differential equations require some form of spatial discretization, or mesh of nodes, at which the solution is specified. The nature of the mesh is an important factor in determining the accuracy and stability of the method as well as the type of partial differential equation that can be solved. For example, Finite Difference Method is based on a regular spatial discritization, and Finite Element Method divide the plane into triangles or rectangles, often with an irregular distribution.

In lagrangian techniques the mesh is required to evolve with the solution, that is, mesh nodes move during the calculation. The Lagrangian type of the specification is useful in special contexts. An example is the case of advection in which the mesh nodes are attached to a deforming medium. Although an evolving mesh allows for material properties to be accurately transported at the nodes, large displacements quickly result in severe mesh distortion which in turn increases numerical instability and restricts accuracy.

Generally, Eulerian type of specification is use in computational fluid dynamics. In eulerian techniques, since the nodes is fixed, the spatial mesh need not to be made to change.

Natural Element Method is a new Lagrangian method which overcomes these problems proposed Jean Braun et al. This method is based on the fundamental geometrical concept of natural neighbours. The result is a the method which can be applied to problems where traditional eulerian and lagrangian techniques fail; for example, those involving large deformation, or fluid-solid interactions, The two essential features are the way in which both the mesh nodes and the connections between nodes are updated during the calculation to maintain an appropriate well shaped triangulation, and the use of natural neighbour interpolation and their derivatives to interpolate smoothly between arbitrarily distributed nodes. They use a two dimensional example of a sinking elasto plastic plate in a linear viscosity fluid to illustrate these features.

In our research this method is applied to solve Navier Stokes equation. This problem is more difficult than their example. But adding or removeing the nodal point on the mesh, we success to solve the problem.

But using the method, the matrix to solved is more complex than other methods. Accordingly, it takes longer time in the calculation to solve the matrix. Furthermore, its interpolation , called Natural Neighbour interpolation , require much arithmetic operations to make the matrix.

For these reasons, to decrease the computational time, we sellect the way of use parallel computing. The various forms of parallel numerical algorithm that speed up computations are as different as the number of researchers working on the problem. However, most of the recently proposed concurrent computational strategies seem to have a common starting point, namely, domain decomposition.

In this paper, we propose the parallel numerical algorithm for Natural Element Method using domain decomposition. The way of domain decomposition is as follows. All processors have information of nodal point(for example, velocity , pressure) in whole domain. Each processor selects his sub domain to calculation. We describe the parallel implementation of Natural Element Method, for simulating fluid flow. The code is implemented on the Connection Machine CM-5, a massively parallel processor. To use the speed up ratio we evaluate our algorithm. We suggest the possibility of the calculation of parallel Natural Element Method.