

ICM-9212-44 Synthesis of Sequential and Parallel Programs for Finite Element Analysis, Navenn Sharma (dissertation).

ABSTRACT: In this thesis, I develop a coupled symbolic-numeric approach to solve PDE-based mathematical models. Existing software packages to solve these models are written in **Fortran** and provide facilities for frequently used (local) formulations and numerical solution procedures. These “canned” packages can not be used where new formulations, new solution procedures, or parallel execution is required. The present research work is concerned with design and development of a program synthesizer for computationally intensive and problem formulation dependent phases of the solution method. The emphasis is on the *finite element analysis* (**FEA**) method of solution although the techniques developed are applicable for other methods of solution.

The idea is to employ methods from computer algebra to derive element properties like shape functions, stiffness matrices etc. for more than one formulations. The problem specific information, element properties, and the knowledge about numerical analysis are then used to generate sequential and parallel numerical procedures for FEA solution steps. An experimental software system, PIER, is being developed in Common Lisp for the purpose.

PIER features a programming knowledge-base of program schemas that are *instantiated* and *transformed* into special-purpose **F77** code fragments or subroutines required in the FEA solution steps. A very high-level user input specification mechanism enables the modeler to transcribe a textbook-like FEA description and the solution algorithms into PIER input form. The code generator extracts the application domain-*independent* and -*specific* parallelism and schedules the computations on the target computer. Experiments with two different FEA schemes – *element-by-element* and traditional *assembly* approaches are carried out. The generated routines execute in conjunction with an existing FEA package. Currently, the target parallel architectures include the Warp (systolic array) and the Sequent Balance shared memory architectures.