NASA TECH BRIEF

Marshall Space Flight Center

Hybrid Computer Techniques for Solving Partial Differential Equations

Two hybrid (analog/digital) computer techniques can be used for generating approximate solutions to partial differential equations. A preliminary study indicates that these techniques may help overcome the equipment limitations that frequently restrict other computer techniques to solving trivial cases.

In both techniques, the original equation is converted into a set of coupled, ordinary differential equations by quantifying the space variable and using the method of finite difference approximation. Conceptually, the set of coupled equations can be easily solved. However, since the number of equations tends to be large, the required quantity of analog simulators or the required digital storage space can easily exceed the capacity of even the most modern equipment.

The analog problem was surmounted by employing serial solution techniques in a hybrid computer. The equations were solved sequentially in the analog section. However, since each equation contained forcing functions that depended on the solutions to neighboring equations, it was necessary to store the succession of solutions in the digital section. This itself could require excessive storage space.

Several techniques for reducing the required storage area were investigated. All of them stored the functions' values at only a few points and approximated the intermediate values of the functions as needed. Two principal approximation techniques were used: zero-order hold, and polynomial curve fitting.

The test case used was the one-dimensional heat-flow equation, with space quantized into seven discrete intervals between zero and one. The following results were noted: (1) When a zero-order hold was used, the solution converged to the wrong answer. The error could be significantly reduced by shifting the data forward in time by precise amounts, but the error then depended strongly on the amount of shift. (2) Much better results were obtained using curve fitting by a process of linear interpolation. (3) Even better results were obtained using curve fitting by quadratic interpolation.

Notes:

1. For related work involving the application of finite difference approximations to solving ordinary differential equations, refer to NASA Tech Brief B71-10423.
2. Requests for further information may be directed to:

   Technology Utilization Officer
   Code A&TS-TU
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: TSP71-10424

Patent status:

No patent action is contemplated by NASA.

Source: W.M. O'Dowd and J.L. Hammond, Jr. of
Georgia Institute of Technology
under contract to
Marshall Space Flight Center
(MFS-21386)

Category 09