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Automatic Differentiation: Techniques and Applications

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PREFACE

This book is based on the notes for a series of lectures given at the Computer Science Department (Datalogisk Institut) of the University of Copenhagen in the second semester of the 1979-80 academic year. The invitation of Dr. Ole Caprani of that institution to present these lectures, as well as his assistance with the course, is gratefully acknowledged. One of the students, Mr. J. W. Owesen, is also thanked for doing the necessary work to make software from the University of Wisconsin-Madison operational at the University of Copenhagen.

The automatic differentiation of functions defined by formulas proceeds by fixed rules, and is conceptually no more difficult than the translation of formulas into code for evaluation. In spite of this, the automatic calculation of derivatives and coefficients of power series has seemed somewhat exotic to numerical analysts, and perhaps too mundane to computer scientists interested in the creation of ever better languages and systems for computation. The purpose of these notes is to fill this intellectual gap, and show that a powerful computational tool can be fashioned without excessive effort.

The choice of topics presented is dictated by personal interest and familiarity with software which actually works, programs which have proved to be durable as well as effective. On the basis of ideas suggested by R. E. Moore, work was begun at the Mathematics Research Center by Allen Reiter in 1964-65 on software for differentiation, generation of Taylor coefficients, and interval arithmetic. This led to interrelated developments in programs for the solution of differential equations, nonlinear systems of equations, numerical integration, interval arithmetic, and a precompiler for the addition of new data types to FORTRAN. (The connection with FORTRAN is one of the reasons for the durability of this software.) This period of activity came to an end in 1977-78 with the departure of Julia Gray, F. Crary, G. Kedem, and J. M. Yohe from the Mathematics Research Center. Significant contributions were made along the way by J. A. Braun, D. Kuba, T. Ladner, T. Szymanski, and H. J. Wertz, among others. The support of the U. S. Army Research Office during the entire period of the development of this software is appreciated.

It is not implied that the subject of these lectures is a closed book; rather, it is an open door for future developments. To this end, each topic has been provided with suggestions for projects ranging from simple exercises to the construction of elaborate computational systems.

The production of these notes was assisted by Carol Gubbins, who did a professional job of preparation of the figures. First and foremost, thanks are due to my wife Fran for untiring patience, support, and help with every step of this project from beginning to end.

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