ginning and his dependence much greater. Coe and Flannery begin with a careful description of the physical environment and a detailed delineation of the several ecological zones comprised therein. Attention is given to both faunal and floral species which might have influenced human habitation. After description and analysis of the artifacts, the authors return to a study of the subsistence of these Formative groups and how they succeeded in making use of what the environment offered. The results are mixed and interesting. The basis of subsistence was sedentary maize agriculture in the rich local soil, which permitted up to three crops a year without land rotation. Vegetables were not found, but probably some had been planted in the cornfields. Several species of fruit were eaten, perhaps cultivated. Meat requirements seem to have been filled largely from the sea: 11 species of fish, 5 of crabs (which were extensively collected), and 24 of molluscs. As at Dzibilchaltun, in Yucatán, species of Mollusca chosen for use varied so sharply from period to period that they could almost replace pottery in the dating of deposits. But, as was not the case at contemporary Dzibilchaltun, the avifauna, both resident and migratory, and the numerous mammals were rarely hunted. This might reflect, as the authors suggest, that subsistence was at such a comfortable level at Ocos that ventures to any considerable distance from home were simply not considered worthwhile. In Yucatán, on the other hand, where slash-and-burn agriculture demanded daily trips to often distant milpas, hunting was probably as much the order of the day as it is now.

Archeology has for two generations been reluctant to allow for the steadily increasing costs of publication. Funds for clearly contributive field studies are not hard to come by in these years, and foundations and often the universities are not loath to pay salaries later for principal officers to complete studies of artifacts and prepare reports of their work. But when it comes to the relatively minor expense of publication, the purse strings tighten. Reports on highly successful and expensive projects are often never published; many linger for years until their usefulness is largely lost; others are condemned to the microfilm or mimeograph. Among those actually printed, many are characterized by poor typography and almost illegible illustrations, often so reduced in size that a lens is needed to use them. The Smithsonian has been most wise in this new series to sacrifice nothing to clear presentation. The print is large and legible, the illustrations excellent, and the format relaxing to the reader. The palatability of this volume is further enhanced by the concise but most readable style of the authors and the excellent organization of material.

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Assessing Accuracy

Interval Analysis. RAMON E. MOORE. Prentice-Hall, Englewood Cliffs, N.J., 1966. 159 pp., illus. $9.

A central problem in numerical mathematics is the calculation of estimates or bounds on the approximate answers obtained. The answers are approximate because an infinite process has been replaced by a finite one or because infinite precision arithmetic (the arithmetic of mathematics) has been replaced by finite arithmetic (the arithmetic of calculation). Often both effects are present. In addition, the answers are approximate because the data are approximate. Causes for this may be uncertainty in physical measurement or truncation of input data (perhaps known to infinite precision) to finite length. An example of the latter occurs when 1/3 has to be stored in a computer.

The approximations mentioned above are sometimes viewed as being due to errors in an exact quantity. The traditional method of error analysis is a *forward* analysis. The object of this analysis is to estimate by how much the computed answer differs from the "exact" answer. Such an analysis is usually very difficult to carry out for error due to the use of finite-length arithmetic. A recent approach has been *backward* error analysis, in which one investigates to which problem the computed answer is the exact solution. This approach has been exploited with great success by J. H. Wilkinson. Theoretical error analysis, either forward or backward, has a number of drawbacks. The analysis is often difficult to carry through. Furthermore, such a theoretical analysis is of necessity an a priori analysis of a certain method for a class of problems (for example, Gaussian elimination for a system of linear algebraic equations). Thus the results do not depend on the particular problem at hand and are therefore not "sharp."

There has been considerable interest in methods by which the computer automatically bounds the error in the answer at the same time that it calculates the answer. A promising approach is through the use of *interval analysis.* In interval analysis, numbers are replaced by interval numbers, that is, by pairs of numbers which denote the upper and lower ends of an interval. The interval numbers are combined according to the rules of *interval arithmetic.* (On a computer, interval arithmetic is performed by software rather than hardware.) The data are interval numbers which are operated on in interval arithmetic, and the answer is given in terms of interval numbers. Giving the data as interval numbers is certainly reasonable since the data are, after all, generally not exact. Thus the chemist's measurement of a quantity as $.152 \pm .0005$ may be thought of as specifying the interval number [.1515, .1525].

The author of this book is an authority on his subject. Much of the material presented results from his own research. After introducing interval numbers, he discusses interval arithmetic and a metric topology for interval numbers. He then applies interval analysis to a variety of problems including function evaluation, root-finding, and the solution of integral and differential equations.

Interval analysis does not provide a panacea. To get the benefits of interval analysis, one cannot simply write an algorithm in a procedure-oriented language such as FORTRAN and specify that the arithmetic to be used is to be interval arithmetic. Constructing an appropriate algorithm so as to be able to reap the benefits of interval analysis is a matter for an expert. It is clear that a great deal of research remains to be done in the area of automatic error analysis. Interval analysis is an important tool, and Moore gives an authoritative account of it.

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