85.2 The IASPEI Seismological Software Library

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1. Introduction

Since computers became widely available in the early 1960s, seismologists have been using them for data acquisition, processing, and analysis, as well as theoretical computation and modeling. For example, the book by Doornbos (1988) contains a collection of seismological algorithms with the corresponding computer programs available on tape or disk from the World Data Center A for Solid Earth Geophysics. The introduction of personal computers in the early 1980s further revolutionized the use of computers for scientific research. Instead of expensive mainframe computers that required a large staff to operate, inexpensive personal computers allowed creative applications to be implemented by individuals with a shoestring budget.

The author was conducting experiments in a quarry for the Defense Advanced Research Projects Agency in the mid-1980s and implemented a simple real-time seismic monitoring system for fieldwork using the personal computer technology. At about the same time, many geophysicists started using personal computers and the author was appointed to chair a committee on personal computers by the American Geophysical Union (AGU). However, the author was not able to persuade AGU to publish software to be prepared by the committee because AGU correctly identified that it would be a money-losing proposition as the market for geophysical software is too small. The committee was soon disbanded.

In 1988, IASPEI established a Working Group on Personal Computers to promote the sharing of seismological software and hardware information among seismologists, and the author was appointed as its chair. An editorial advisory board was created, consisting of Hiroo Kanamori (chair), R. D. Adams, V. Cerveny, E. R. Engdahl, Y. Fukao, R. B. Herrmann, E. Kausel, V. Keilis-Borok, B. L. N. Kennett, and S. K. Singh. In addition to the author, the Working Group consisted of John Lahr and Frank Scherbaum as associate editors, and Mariano García-Fernández as the Shareware Library editor (See Chapter 85.3 by García-Fernández).

To achieve its stated goal, the author realized that seismological software must somehow be published. Unfortunately, funding agencies, such as the US National Science Foundation and the US Geological Survey, were not persuaded. As a last resort, the author approached the Seismological Society of America (SSA). SSA agreed to collaborate with IASPEI to publish the IASPEI software on the conditions that (1) the software project be self-supporting, (2) an SSA-designated examiner must give prepublication approval, and (3) SSA members can buy the software volume at half price.

Since IASPEI itself does not have any money to support the project, the project depended on volunteers, and the author (as the editor) did everything possible to minimize production costs. Robin Adams, then secretary-general of the IASPEI, persuaded UNESCO to order copies for free distribution in the developing countries, and S. K. Singh, a member of the editorial advisory board, persuaded the Third World Academy to do the same. Also, many SSA members ordered the software. Within about a year, the IASPEI software publication project became self-supporting.

During the 12 years after the Working Group was established, six volumes were published. Each IASPEI software volume includes the executable code and examples on floppy diskettes, as well as printed documentation for IBM-compatible or Intel-based personal computers running the Microsoft DOS operating system. These volumes are available for sale (until the existing stocks are exhausted) from the Seismological Society of America, 201 Plaza Professional Building, El Cerrito, CA 94530, USA (Phone: 1-510-525-5474; Fax 1-510-525-7204; e-mail: *krowe@seismosoc.org*; Web site: *http://www.seismosoc.org*).

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Source-code packages are available from the SSA for the first four volumes of the IASPEI Software Library. URL *http://lbutler.geo.uni-potsdam.de/service_p.htm* has the source code of Volume 5. To remedy the fact that the source code for Volume 6 was not published, we archive it in the subfolder for Chapter 85.2 on the attached Handbook CD.

2. A Brief Summary of the IASPEI Software Library Volumes

2.1 Volume 1: "Realtime Seismic Data Acquisition and Processing" (Lee, 2000a)

Volume 1 (1st Edition, 1989; 2nd Edition, 1994; Y2K Version, 2000) contains programs for real-time seismic data acquisition, processing, and analysis. It includes a description of the hardware implementation for a PC-based real-time seismic system and programs to perform seismic data acquisition, interactive picking of seismic phases, filtering, spectral and coda Q analysis, and earthquake location. The second edition of this volume contains software revisions and several new programs. Included are supports for the USGS digital telemetry standards and PC-SUDS format. The Y2K version includes updates and additional programs for Y2K compliance.

Worldwide, over 200 seismic networks and arrays have used the Volume 1 software. This software contributed to the success of predicting the Mount Pinatubo volcanic eruption (Kerr, 1991) and to the rapid reporting (within 102 sec) of accurately determined location and magnitude with a shake map of the disastrous Chi-Chi (Taiwan) earthquake in 1999 (Shin *et al.*, 2000; Wu *et al.*, 2000).

2.2 Volume 2: "Plotting and Displaying Seismic Data" (Lee, 2000b)

Volume 2 (1st Edition, 1990; 2nd Edition, 1994; Y2K Version, 2000) is a companion to the first volume. It contains 12 computer programs for plotting seismic data on the monitor screen and generating hard-copy plots. It includes a three-dimensional data-viewing program for rotating, enlarging, or shrinking objects and data points. The second edition of this volume contains several new programs for plotting seismic waveform data in PC-SUDS format. The Y2K version includes updates and additional programs for Y2K compliance.

2.3 Volume 3: "Digital Seismogram Analysis and Waveform Inversion" (Lee, 1994a)

Volume 3 contains two major programs: SeisGram by Anthony Lomax for interactive analysis of digital seismograms, and SYN4 by Robert McCaffrey, Geoffrey Abers, and Peter Zwick for inversion of teleseismic body waves. This volume (published in 1991; updated in 1994 to support PC-SUDS format) is a toolbox for seismological research, especially on broadband digital data, and has been used in several training courses worldwide.

2.4 Volume 4: "Bibliographic References and BSSA Database" (Lee, 1994b)

Volume 4 (published in 1994) is a toolbox for managing bibliographic information and includes programs to automate the reference preparation in manuscripts and to manage a user's own references. It also includes a bibliographic database of all papers published in the *Bulletin of the Seismological Society of America* (1911–1993) and some frequently cited articles for seismologists. Recently, the Seismological Society of America established the BSSA Web Index, which is up-to-date and searchable online, by using the BSSA data prepared in Volume 4 and extending the coverage to the current issue. It is open to everyone on the SSA Web site: *http://www.seismosoc.org/*.

2.5 Volume 5: "Programmable Interactive Toolbox for Seismological Analysis" (Scherbaum and Johnson, 1992)

Volume 5 is a Programmable Interactive Toolbox for Seismological Analysis (PITSA) by Frank Scherbaum and James Johnson, and includes a course on "First Principles of Digital Signal Processing for Seismologists." The manual and PC-version code were published in 1992. A version of PITSA for Sun workstations is available from the IRIS Data Management Center at *ftp://ftp.iris.washing.edu/pub/software/PITSA/*. This volume has been used in several training courses worldwide.

2.6 Volume 6: "Algorithms for Earthquake Statistics and Prediction" (Healy *et al.*, 1997)

Volume 6 contains three software packages: SASeis by Tokuji Utsu and Yosihiko Ogata, UpDate by P. N. Shebalin, and M8 by V. G. Kossobokov. SASeis contains ten programs for statistical analysis of seismicity. M8 is an algorithm using pattern-recognition techniques for intermediate-term earthquake prediction (based on an the analysis of smaller-magnitude earthquakes from an earthquake catalog), and Update is an algorithm to aid the preparation of input data for the M8 program.

3. Discussion

The rapid changes in computer hardware and software have rendered many of the published IASPEI software library volumes obsolete. Although the speed of personal computers now is hundreds of times faster than before, the complexity of operating systems makes software development far more difficult. As financial support for seismological research becomes more competitive, most seismologists can no longer afford to

spend as much time on such volunteer work as would be needed to maintain and update the software library. The IASPEI Software Library achieved some modest success, but it is being phased out—in fact, the IASPEI Working Group on Personal Computers was disbanded in 1999.

The traditional way of publishing seismological software on paper and disks is just too expensive to be supported by a limited sale. If authors are willing to share their software, it can now be easily made available via the Internet.

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