Special Topics

Music Software for the Visually Impaired

Efforts to enlist the help of the computer in enabling blind musicians to read music date back some considerable time. Braille codes for music actually pre-date, as best we are aware, all schemes for machine encoding for computer applications, and in this respect blind musicians have already played an important role in the evolution of music encoding. Braille codes for music vary somewhat from country to country, but all can be described as alphanumeric.

National dialects of Braille are recognized in a system for the creation of Braille music editions that has been developed at the Centre TOBIA of the Université Paul Sabatier in Toulouse. Originating in 1982, the programs now run on an IBM PC. Input differentiates score-specific information (clef, time signature, etc.) from performance-specific information (pitch, duration). A non-formatted Braille music document is created. From it, an edition can be requested in either the French dialect (fragment by fragment) or the American (bar over bar). Further information may be obtained from M. Truquet or N. Baptiste at 118, route de Narbonne, 31062 Toulouse Cédex, France. See also p. 34.

The Ohteru musical robotics group at Waseda University in Tokyo seems also to have invested a substantial amount of time in an effort of this kind. A conversion of its Standard Musical Expression (SMX) code to Braille has been in place for several years. The representation scheme used in the Braille music system was shown in the 1987 *Directory* in Illustration #3.

Another approach to the production of musical editions for the visually impaired is the creation of large-print scores. Leland Smith's SCORE program has produced hundreds of very-large-print editions through a project supported by the Library of Congress. The prevalence of scalable fonts makes this an increasingly practical option for many printing programs.

Among recent efforts, Mark Glover is developing a system designed to translate automatically an ink-print representation of a musical score into the Braille equivalent. His work is being carried out at the Royal National Institute for the Blind in Peterborough, England, on an IBM PC compatible.

The corollary need of the blind to generate conventional scores for sighted musicians is not specifically addressed in any software of which we are aware. MIDI music entry offers some possibility of this kind to blind users but fails to provide an effective way of editing the output. At the University of Oslo some macros have been written to enable a blind student to write and listen to theory exercises using *Finale*.

Artificial Intelligence and Music

One of the most rapidly growing interfaces between music research and technology is that linking music with artificial intelligence. Three workshops on artificial intelligence and music were held during 1988 and more are following in 1989.

The American Association for Artificial Intelligence has held, in the context of its annual meetings of 1988 and 1989, a one-day workshop on music and artificial intelligence. Some of the topics covered in the August 1988 meeting in St. Paul, Minnesota, were "An Expert System for Harmonic Analysis of Tonal Music" (H. J. Maxwell) and "Issues of Representation in the Analysis of Atonal Music" (John Roeder). This is a small sample drawn from a list of 19 papers. The meeting was attended by more than 40 researchers from Belgium, Canada, Israel, the UK, and the US. For the AAAI, it was the first time "research carried out within a humanities context" received formal attention. The meeting of August 20, 1989, was held in Detroit.

Copies of the 1988 workshop proceedings, which are separate from the main body of conference proceedings, are available for US $20 plus $2.40 for shipping from the AAAI, 445 Burgess Drive, Menlo Park, CA 94025, USA (some items are in press in scattered publications). Those interested in interacting with the group in future workshops may contact any of the following: Mira Balaban (Ben Gurion University), Kemal Ebcioglu (Thomas J. Watson Research Center), Marc Leman (University of Ghent), or Linda Sorisio (Los Angeles). Please see the address lists at the back of this volume for further particulars.

An entirely independent First International Workshop on Music and Artificial Intelligence was held in St. Augustin, FRG, on September 15 and 16, 1988. It was organized by Christoph Lischka under the auspices of the Gesellschaft für Mathematik und Datenverarbeitung. Its purpose was to identify AI techniques of possible value in musical applications and to suggest possible directions for future research. The participants included Mira Balaban, Antonio Camurri, David Cope, Mark Leman, and John Rahn.

On June 22 and 23, 1989, a European Workshop on Artificial Intelligence and Music took place in Genoa, Italy. Jointly sponsored by the Italian Computer Music Association (AIMI) and the computer music laboratory at the University of Genoa, the workshop included presentations on cognitive musicology, expert systems, neural networks, knowledge representation, and compositionally oriented topics.

Finally, a session on artificial intelligence and music was held as part of an electronic music conference in Sorrento, Italy, from October 28 to 31, 1988. Christoph Lischka described a neural network for harmonization in the style of J. S. Bach, while Kurt Hebel and Carla Scaletti of the University of Illinois discussed the Kyma and Javelina systems and their relationship to musical composition.

Some papers from these sessions have recently been published by the *Computer Music Journal*. Others are being collected in a book to be published by MIT Press.

Musical Information Processing Standards

The proliferation of software programs to print music has engendered increased interest in musical notation itself. The British Standards Institution has considered revising its *Recommendations for Presentation of Music Scores and Parts* of 1982. This document, created under the auspices of the Documentation Standards Committee, gives succinct advice about the grammar of musical notation. In the US two groups for the reform of musical notation have been convened. The Music Notational Modernization Assocation is at PO Box 241, Kirksville, MO 63501. The other, which is concerned with the representation of electronic and other modern music, is informally organized in Northern California.

Meanwhile, the work of the Musical Information Processing Standards committee seated by ANSI in 1986 continues, with three one-week meetings a year being the norm. Diverse locations are chosen, to facilitate interaction with different constituencies. The committee met in San Diego in February, in San Jose in July, and was scheduled to have a meeting coincident with the International Computer Music Conference in Columbus, Ohio, in November 1989.

Over the past year the sound aspect has been strongly emphasized, partly in response to the Computer Music Association's having solicited funding for two positions on the committee. The funding bodies are the Yamaha and Xerox Corporations. Attendance at the meetings is frequently sparse, but corresponding members of the committee continue to be numerous and vocal.

In addition to representatives of the music industry, the MIPS membership includes Garrett Bowles, representing the Music Library Assocation, and Craig Harris, representing the Computer Music Assocation. Both provide regular reports to their sponsors.

The standard being pursued is provisionally called Standard Music Description Language (SDML). It is described in the Journal of Development, which is edited by Alan Talbot of New England Digital. The Journal is divided into three parts, one dealing with objectives and methodology, one with time-based events, and one with technical descriptions and formal definitions.

Periodic discussions of the mission of the committee surface. Dorothy Gross has authorized reproduction of the material shown on the following pages, which encapsulates the multifaceted nature of the task of creating a standard for musical information.

Musical Information Processing Standards:

Requirements for visual and aural expression of musical attributes

In this chart, prepared by Dorothy Gross for the Musical Information Processing Standards committee, the diverse aural and visual representations of several musical attributes (structure, time, pitch . . .) are reviewed in relation to the specific requirements of different kinds of applications (publishing, education . . .).

Use	Structure	Time	Pitch	Timbre	Lyrics	Others
Publishing:						
Music	V	V	V	B	V	V
Nonmusic	V	V	V	B	V	V
Education:						
Music	R	R	R	R	R	R
Nonmusic	A	B	B	B	B	B
Student	B	B	B	B	B	B
Research:						
Music	R	A	A	A	B	A
Nonmusic	B	B	B	B	B	B
Library	B	B	B	B	B	N
Creation:						
Composer	R	R	R	R	R	R
Arranger	R	R	R	R	R	R
Copyist	V	V	V	B	V	V
Recording:						
Music	B	A	A	A	A	A
Media	A	A	A	A	A	A
Applications:						
Business	A	A	A	A	B	A
Sound	A	A	A	A	A	A
Hobby	B	B	B	B	B	B

Key --

A = extended aural set needed
B = only the basic set needed
N = none needed
R = range of needs
V = extended visual set needed

Dr. Gross comments:

The real world is more complex than this chart indicates, with interaction among the different categories of use. But the chart serves to illustrate different kinds of uses for computer applications to music.

First, the direct uses are for software tools that interface between the standard representation and more user-friendly forms. Designers and developers of these tools come into direct contact with the SDML [standard markup language], and may or may not be musicians. People involved with direct use are apt to be software professionals.

After the direct uses comes the use of the tools for musical purposes. This use involves computers but does not require direct contact with the standard itself. However, the intermediate user is concerned with a specific musical application.

The final level, the end use, consists of the music applications themselves. People involved at this level may not use computers at all. For example, an end user might be a person listening to a computer-generated recording.

Since the intermediate level combines computer literacy and musical intentions, this level is the target MIPS use . . . . It is assumed that the target users consider input from both software developers (what can be done) and music consumers (what should be done).

These levels are differentiated in the following table:

Use of MIPS	Pub- lish- ing	Educa- tion	Re- search	Crea- tion	Re- cord ing	Appli- ca- tions
Direct use	gra- phics tools	educa- tional tools	data- base tools	music tools	digi- tal sound	gene- ral tools
Target use	publi- ca- tions	CAI	data- bases	scores	disks & tapes	back- ground music
End use	read- ing	learn- ing	analy- sis	per- form- ance	music lis- tening	other lis- tening

Musical Data Acquisition by Optical Character Recognition

Research into techniques for automating the process of musical data acquisition through the use of optical scanning has been stimulated in the past few years by the easy availability of digitizing hardware. The difficult task of decoding bit-mapped images of music into useful information about musical content is one that has been pursued for approximately twenty years. A comprehensive review of earlier work in the field can be found in "Acquisition, Representation and Reconstruction of Printed Music by Computer" by N. P. Carter, R. A. Bacon, and T. Messenger in *Computers and the Humanities* 22 (1988), 117-136.

We reported on current projects and principles of optical scanning in the 1987 *Directory* (pp. 84) and 1988 (pp. 38-40). Among the efforts previously mentioned, the Waseda and Osaka University groups demonstrate the greatest level of sophistication and the highest degree of accuracy. The Inokuchi group at Osaka is attempting to create "playable" information from a printed page; they quote accuracy rates for nineteenth-century piano music in the range of 90% to 95%. The Ohteru group in Tokyo uses the acquired musical information for diverse purposes in the context of robotics.

The objective of the projects mentioned below is to capture data from either printed or handwritten sources and then to decode it into intelligent information sufficient to support new editions and other uses.

At the University of Surrey, Nicholas Carter and his colleagues continue their work in the UNIX environment. The project has migrated to a Sun workstation. Data acquisition occurs in a UNIX environment; printing is done with DOS. The conversion of handwritten music to printed music via the generation of Leland Smith's SCORE code is shown in the accompanying examples. Carter's thesis was completed in March 1989; the project continues through 1990 on a grant from the Leverhulme Trust.

At the Mathematics Institute at the University of Cardiff, Wales, Alastair Clarke's work with an IBM PC continues. His system is able to recognize single-line melodies with about 90% accuracy where the content is limited to whole, half, quarter, and eighth notes, rests corresponding to these values, accidentals, and clef signs. The work is reported in "Using a Micro to Automate Data Acquisition in Music Publishing" in *Microcomputing and Microprogramming* 24 (1988), 549-54.

Research in Optical Scanning

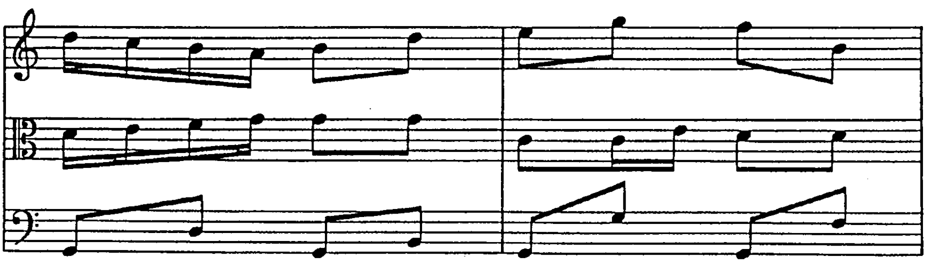
Contributor: Nicholas P. Carter
Place: University of Surrey, Guildford, England
Input environment: UNIX (Sun workstation)
Output environment: DOS

(a) A short handwritten musical example ;

(b) A SCORE data file created by processing the image:

```
IN 1
0
M3/BA/G2/D3/G2/B2/M3/G2/G3/G2/F3/M3;
8/8/8/8/8/8/8/8;
;
1 2/3 4/5 6/7 8;
;
IN 2
SP 1
AL/D4/E4/F4/G4/G4/G4/C4/C4/E4/D4/D4;
16/16/16/16/8/8/8/16/16/8/8;
;
1 4/5 6/7 9/10 11;
;
IN 3
SP 1
TR/D5/C5/B4/A4/B4/D5/E5/G5/F5/B4;
16/16/16/16/8/8/8/8/8/8;
;
1 4/5 6/7 8/9 10;
;
```

(c) Reconstruction of the score from the data shown in (b):



At McGill University in Montreal, Bo Alphonce leads a group of researchers intending to "develop a system for fully machine-implemented optical score recognition" on a Sun workstation. They are using a Datacopy 730 scanner. Their work was reported in "Optical Music Recognition: A Progress Report," a paper presented at the Eighth Symposium on Small Computers in the Arts, which occurred in Philadelphia in November 1988.

In its preliminary stage, this work concentrated on clef signs, half- and quarter-notes, flagged and beamed notes, accidentals, and dots of prolongation in monophonic examples. In contrast to other efforts that attempt to disentangle overlapping symbols through bounding boxes and feature extraction, the McGill team uses a projection profile for initial differentiation of large elements. The technique was described in the M.A. thesis of one of the team members, Ichiro Fujinaga. It was entitled "Optical Music Recognition Using Projections." A near-perfect accuracy rate was achieved with training samples.

William McGee's project in the Department of Electrical Engineering at the University of Ottawa attempts to translate from musical manuscript to DARMS code. An IBM PC and Hewlett Packard ScanJet are used for input; Stephen Dydo's Note Processor provides output. McGee is also working on real time transcription of polyphonic music.

Christian Fluhr and Joseph Abouassly are working on pattern recognition programs to facilitate optical scanning of printed music at the Institut National des Jeunes Aveugles in Paris.

Databases of Musical Information

Research at CCARH

DATABASE DEVELOPMENT

The creation of databases containing complete machine-readable transcriptions of the major repertories of classical music is one of the main goals of the Center for Computer Assisted Research in the Humanities. At the present time, the Center's primary focus is on works of the eighteenth century.

The works are encoded in such a way as to permit multiple uses. These range from simple retrieval for display, searching, and playback to manipulation for editing, arranging, printing, analysis, and synthesis. Extensive study has been devoted to encoding systems in an effort to develop a representational scheme of optimum clarity and comprehensiveness.

Data entry is accomplished in two stages. The first stage involves the entry of pitch and duration information. Each part is entered separately from an electronic keyboard by one of the Center's data specialists. Other kinds of information, such as text underlay, tempo, dynamics, instrumentation, articulation, and ornamentation, are encoded alphanumerically in the next stage.

Visual and aural data verification routines are utilized at several points. Draft prints of encoded parts are checked visually against the source after the first stage of input. Data entered in the second stage is verified by careful examination of the printed score.

SOURCES, HARDWARE, SOFTWARE

The sources on which data entry is based include unedited manuscripts and early prints as well as out-of-copyright editions and modern transcriptions of early works. Each of these kinds of sources requires slightly different approaches to the creation of a complete machine-readable transcription. Elements of information that originated with a composer, scribe, or editor are differentiated from one another, and access to these individual layers of information is supported by the encoding.

The software for entry, storage, and printing has been developed by Walter B. Hewlett from 1983 to the present. Extensions and refinements continue to be made. The IBYCUS operating system, designed by David Woodley Packard, has been employed for the development of the data entry and storage systems, which use a Hewlett Packard 1000 minicomputer. Work is currently in progress to implement these systems on a UNIX workstation.

The databases are system-independent. Application programs can be written for any computer environment. It is anticipated that the first sample diskettes of data will be made available in the later part of 1990. Eventual distribution via a mass storage medium, such as CD-ROM or Digital Audio Tape, is intended. Documentation of the representational system and file structure employed is currently in preparation.

MACHINE-READABLE REPERTORIES

In the summer of 1989 the contents of the Center's databases included the following works:

J. S. Bach: *The Well-Tempered Clavier*, Books I and II, the French and English Suites, the Brandenburg concertos, the orchestral suites, works for violin and harpsichord, miscellaneous works for harpsichord solo, the chorale harmonizations, the passions (including both versions of the St. John), the B-Minor Mass, and approximately six dozen cantatas. These machine-readable transcriptions are based primarily on the Bach Gesellschaft edition.

Corelli: the 60 sonatas from Opp. 1 through 5 and the 12 *Concerti grossi*, Op. 6. These transcriptions are based on seventeenth-century printed sources from Rome and Amsterdam and on the Augener edition.

Handel: the sonatas, overtures, and concertos found in Opp. 3, 4, 6, and 7; miscellaneous keyboard and instrumental works; one opera (*Radamisto*) and one oratorio (*Susanna*). The longer works are based on Handel's autograph scores. Chrysander edition provides the basis for the transcriptions of the instrumental works. *Susanna* was professionally performed and recorded from scores and parts produced at the Center in September 1989.

Telemann: the sonatas, overtures, and suites of the *Tafelmusik*, approximately half of the 72 cantatas in the *Gottesdienst* of 1731/32, the recently discovered serenata *Deutschland grünt und blüht im Friede*, edited by Wolfgang Hirschmann, and the newly attributed opera *Orpheus*, edited by Peter Huth. The *Tafelmusik* and cantata encodings are based on eighteenth-century prints. The serenata has been newly edited by Wolfgang Hirschmann.

Many of the Center's projects are pursued in collaboration with cooperating institutions and performing organizations. The Telemann Database, for example, is organized as a collaboration between the Center and the Magdeburg (GDR) Telemann Zentrum. Other collaborators include the University of New South Wales (Australia) and Philharmonia Baroque Orchestra.

The Center provides archiving facilities for other large bodies of encoded musical data. All surviving data from the Josquin project maintained at Princeton University in the 1960's and 70's have been read into its system.

The SCRIBE Database of Fourteenth-Century Music

An array of projects is associated with the program listed as SCRIBE in the following section of this book. Several linked databases store information about source locations, discographies, descriptions of performances, iconographical evidence, and so forth. A bibliographical database lists 3058 works of the fourteenth century in 5720 locations. More than 1000 descriptive documents and more than 500 paintings are cited.

A very substantial quantity of music has also been encoded. It is estimated that 95% of all monophonic chant (3453 works, as of early 1989) has been encoded. In entry of this material, neume names are assigned. Gaps separating neumes can also be represented. In analytical routines neume names can be stripped out, facilitating the comparison of diastemmatic notation of the fourteenth century with non-diastemmatic notation of the tenth.

Data can be converted to a compacted pseudo-ASCII code and exported to a structure database. There are separate file structures for sacred/monophonic and secular/polyphonic pieces. Facsimiles of monophonic music can be output to a plotter. Since no rhythmic values are assigned, scores cannot currently be created. [See also p. 53.]

SCRIBE software is currently being used at the University of Heidelberg for management of the Cappella Sistina project, a large multi-faceted database project concerned with Renaissance music for the Vatican. In addition to Helmut Hucke and Adelbert Roth at Heidelberg, users of SCRIBE include Andrew Hughes at the University of Toronto and Howard Brown at the University of Chicago.

Opera Omnia

The Center hears regularly from publishers and scholars reporting on the use of the computer in the production of collected editions. Although we did list such projects in 1985, 1986, and 1987, we have discontinued the practice. Many widely respected publishers are producing editions by computers. The programs they use are of interest if they are generally available to the public. Most firms with computer-produced output work in the first instance from hand copy.

Groups of scholars adopting a single piece of software for music printing are creating databases of musical information which we would be happy to list if we can be pursuaded that the data is available for uses other than printing. Commercial programs often intend their codes to be opaque. This has the virtue of safe-guarding trade secrets, but it limits the usefulness of the data encoded.

We would especially encourage editorial bodies contemplating involvement in such schemes to negotiate with software providers for assistance in creating searchable files of musical information unencumbered by the printing and formatting commands. These could be used far into the future for answering questions that the availability of an electronic score is likely to stimulate.