John Snell
Timbre Engineering
Box 337
San Geronimo, California 94963 USA
cmj@timbre.com

How Did *Computer Music Journal* Come to Exist?

[Editor's note: To celebrate the 30th year of *Computer Music Journal's* publication, we invited the founder and original Editor, John Snell, to contribute this article about the *Journal's* origins.]

It was already clear in the 1970s that digital electronics and software offered the potential to transcend limitations of acoustic instruments and traditional scores. Yet early musical exploration with computers revealed the need for a better understanding of the fundamentals. Unfortunately, to gain such knowledge presented formidable challenges: comprehending psychoacoustics, the physics of acoustic instruments and reverberation, and the mathematics of digital signal processing; exploring the ergonomics of human interfaces (for performance with real-time expression); integrating the microscopic level of detail into musical composition; and designing efficiently structured software and computer architecture for real-time control and performance of multiple synchronized channels of sound. To investigate all these areas, composers had to digest graduate-level books, journals, and conference proceedings, each addressed to specialists in a particular discipline.

Seed

This journal was born from the sharing of multidisciplinary research and ideas in the early artificial intelligence (AI) laboratories and computer science departments of Stanford University, Massachusetts Institute of Technology (MIT), Carnegie Mellon University (CMU), and other universities, as well as in research centers like Institut de Recherche et Coordination Acoustique/Musique (IRCAM) and Bell Laboratories in the early to mid 1970s. The benefits of this sort of open, cooperative approach can be recognized in the more familiar growth of GNU and related software (e.g., Linux) over many years.

With a philosophy like that expressed in the book *Pay It Forward* (Hyde 1999) and the corresponding film (Leder 2000), I founded and edited *Computer Music Journal* because I wanted to share the kind of multidisciplinary approach to music I had explored as a student (with support from the National Science Foundation). During my formal education (before the advent of personal computers, digital music instruments, and compact discs) there were no degree programs in computer music. Yet many of us with access to computers realized their musical potential. I appreciated the intelligent professors I was able to study with at Carnegie-Mellon University's electrical engineering program, as well as in music theory and composition, computer science, physics, audio/video, calculus, advanced mathematics, and the physiology and psychology of perception. Work experience in the engineering lab of CMU's Computer Science Department was valuable for learning the practical application of theory to the development of state-of-the-art research projects (e.g., crossbar connected multiprocessor, converters, and a graphics display processor).

Through composition classes at the neighboring University of Pittsburgh, I was able to take advantage of the opportunity to compose electronic music and *musique concrète* in a studio set up by Morton Subotnick. This analog studio was originally equipped with a combination of insightful signal-processing and -generation modules designed by Don Buchla, and later with synthesizers from the companies ARP and EMS. With support from Angel Jordan (whose help was invaluable) and Raj Reddy, I was able to explore computer music using mainframe and minicomputers at CMU. Later I was grateful to study digital signal processing at Stanford University's Center for Computer Research in Music and Acoustics (CCRMA) and to use its digital audio equipment for research and for creating computer music. Private lessons in composition and theory (especially with William Allaudin Mathieu), as well as classes and workshops in raga (with Pandit Pran Nath), African music (with Hamza El Din and others), and Balkan, Arabic, and Balinese music helped broaden my understanding of music.

Computer Music Journal, 30:1, pp. 10–20, Spring 2006

Figure 1. Cover of the first issue of Computer Music Journal *(1977).*

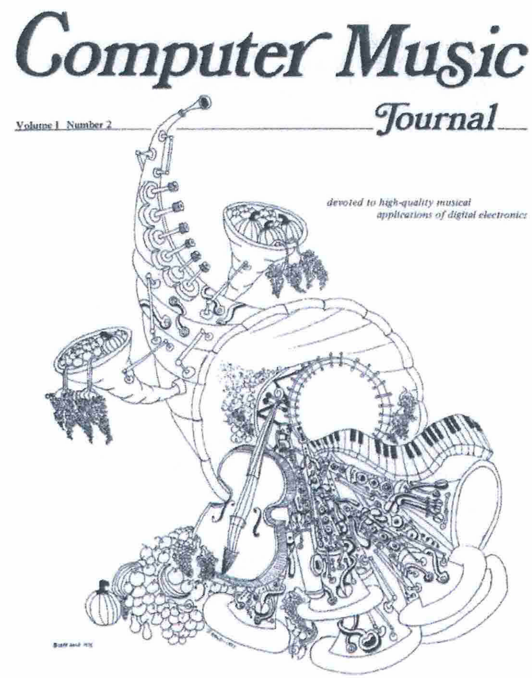


Figure 2. Volume 1, Number 2.

I was also influenced by other nonwestern practices that may be related to thinking "out of the box" (releasing conditioned limits of tradition or convention). Vipassana (Goldstein 1976, Goldstein and Kornfield 1977), Zen (Suzuki 1970), and related forms of meditation focus concentration, allowing one to simply experience reality without preconceptions. They open perception and help one let go of bias, supporting the practice of scientific observation with clarity of mind. I have found that these practices also enhance insight and creativity in design, composition, and improvisation. As one follows his or her deep interests throughout life, multidisciplinary education can take a variety of forms.

In starting the *Journal*, I greatly appreciated encouragement from James A. Moorer, Max Mathews, and other researchers. Believing that it would provide a place to publish articles from CCRMA, IRCAM, Bell Labs, University of Illinois, MIT, CMU, Xerox PARC, and numerous other research centers, I described *Computer Music Journal* at the first International Computer Music Conference (ICMC) (ICMC was heir to the annual Music Computation Conferences). Flyers listing the content of the *Journal* were distributed at this ICMC, as well as at CCRMA and other locations during the fall of 1976.

The high cost of fast computer systems, which were still inadequate for real-time music synthesis and digital signal processing, led many of us to design our own systems. The Homebrew Computer Club, skillfully moderated by Lee Felsenstein at the Stanford Linear Accelerator, consisted of an eclectic group of engineers and programmers (from Silicon Valley, San Francisco, the University of California at Berkeley, and Stanford University) who shared ideas and resources to help each other develop computers, compilers, and systems—including some digital music, graphics, and video systems. For example, Steve Wozniak and Steve Jobs demonstrated the first Apple computer to the Homebrew Computer Club in the spring of 1976. To stimulate inter-

Figure 3. Volume 1, Number 3.

Figure 4. Volume 1, Number 4.

est in the programming and engineering challenges of computer music, I distributed flyers for the *Journal* at the Homebrew Computer Club.

Research Publication Versus Popular Commercial Pressure

Computer music was in its infancy during this period, limited by knowledge, software, hardware, and expense. Although useful for composition, the powerful mainframes and minicomputers used by researchers were inadequately designed to accommodate real-time, interactive performance by musicians. It was obvious that the ability of affordable microcomputers to perform musical applications would eventually surpass even that of the supercomputers of the time. However, in 1976, microcomputers were severely limited in speed, architecture, precision, memory, and software. For example, microcomputers lacked a multiplier unit for real-time signal processing and enveloping. The ability to change pitch in real time, requiring at least 20 bits to maintain tuning, was limited by the 8-bit arithmetic-logic unit in popular microcomputers.

The original publisher of this journal was the People's Computer Company (PCC), which derived its name from making programming accessible to youth and the general public (before computers were common household items). An offspring of the Portola Institute (the organization known for spawning the *Whole Earth Catalog*), PCC was a nonprofit publisher of computer information in Menlo Park, California, next to Stanford University. Bob Albrecht, a founder of PCC who was aware of my background in computer music, invited me to write a book about making music with computers. I was concerned about the musical limitations of early microcomputers, the systems on which popular computer publications focused at the time. Instead of a book for PCC, I started by writing a bibliography of the research and theory that formed a foundation for

Figure 5. Volume 2, Number 1.

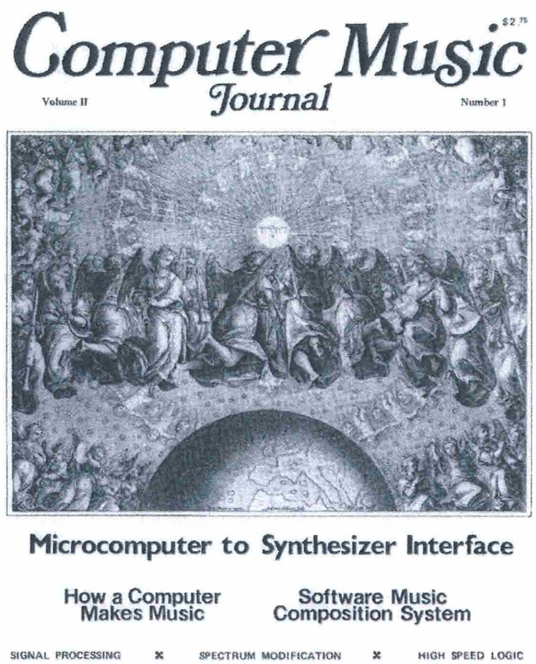
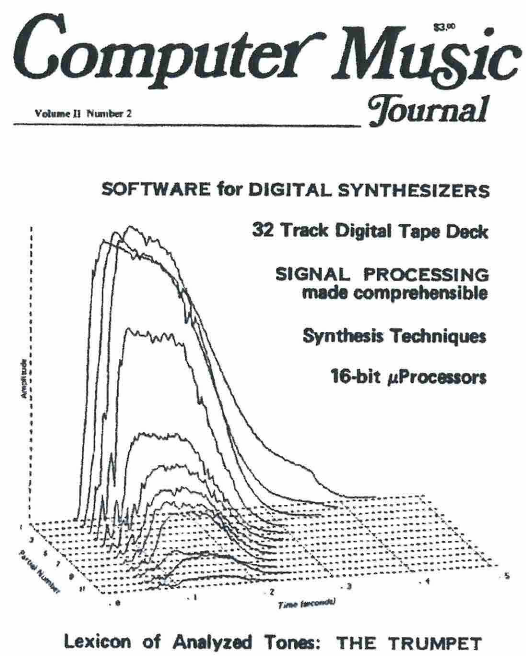


Figure 6. Volume 2, Number 2.



computer music. This bibliography was intended to help readers understand what was needed to create digital music as sonically rich as that produced with acoustic instruments. My *Computer Music Bibliography* (Snell 1976) was published in the August 1976 issue of *Dr. Dobb's Journal*, edited at the time by Jim Warren for PCC. This bibliography served as the foundation and springboard for starting *Computer Music Journal.*

I am grateful to Bob Albrecht and Dennis Allison of PCC for their impetus, as well as their open attitude toward publishing the *Journal.* (Our paths crossed again in the 1990s when I served with Dennis Allison on the editorial board of Michael Slater's *Microprocessor Report* during the evolution of media processors. Design details and analysis of state-of-the-art integrated circuits are published in *Microprocessor Report* for chip architects and microelectronics engineers.)

If PCC had been primarily profit-driven, *Computer Music Journal* would have been the cheerleader for popular microcomputer applications of dubious musical value owing to the limitations of the early microcomputers. *Byte,* the most popular computer magazine in the 1970s, invited me to produce my journal through their publisher instead of through PCC. The offer of a well-equipped music studio, as well as the gain in income (from PCC's tiny budget of US$ 300/month), were tempting. However, regardless of financial benefit, I had little interest in focusing on computers that were architecturally inadequate for running interesting musical applications. Although a comfortable salary was readily available in Silicon Valley for an engineer with a degree in electrical engineering from a reputable university, my interest in music outweighed my economic needs.

I was more drawn to digital instruments for real-time expression of musical composition, as well as to the design of software and electronics that had the potential to create new music as interesting and complex as music played on acoustic instruments

Figure 7. Volume 2, Number 3.

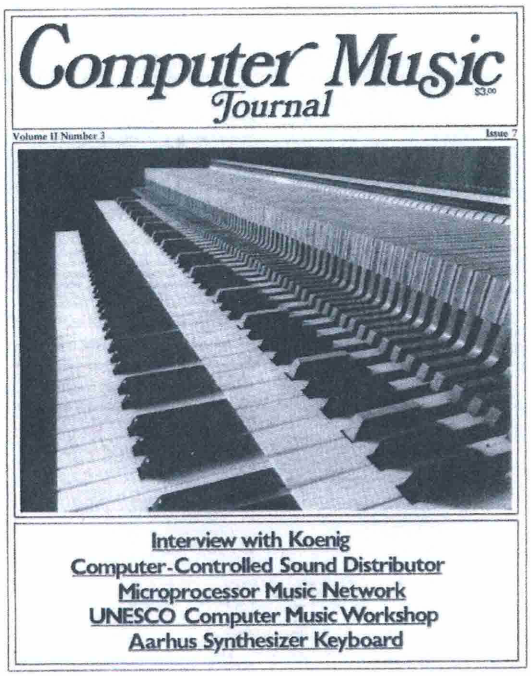
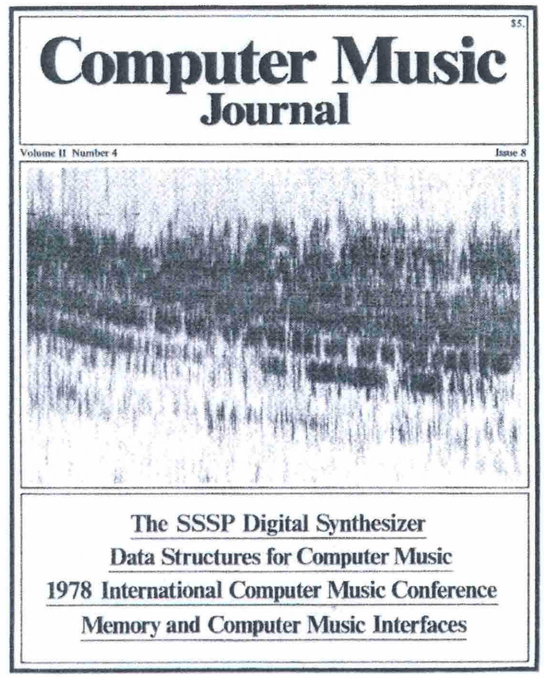


Figure 8. Volume 2, Number 4.



from diverse cultures. I thought that a nonprofit educational organization like PCC would support the *Journal's* research content, enabling it to be more independent of popular opinion.

Influential Models

In considering models for the *Computer Music Journal*, I appreciated the informality of Bernie Hutchins's excellent newsletter, *Electronotes*. I also wanted to include articles on composition and music theory like those published in *Perspectives of New Music*, *Journal of Music Theory*, John Chalmers's *Xenharmonikon*, and *Source—Music of the Avant Garde*. I was very influenced by the *Journal of the Audio Engineering Society*, as well as by the numerous journals published by the Institute of Electrical and Electronics Engineers (IEEE) and the Association for Computing Machinery (ACM). I also hoped to include articles like those published in *Journal of the Acoustical Society of America*, *Acustica*, *Science*, and *Scientific American*. Most of my research in mathematics and psychoacoustics came from books and conference proceedings in university libraries, yet I also wanted to include articles from these disciplines.

Production in the Stone Age

Although it was less technically demanding than my microelectronics and software engineering work, I had grossly underestimated how much time would be required to mechanically typeset, edit, and lay out articles. After years of using virtual "cut and paste" on mainframe and minicomputer video screens connected to a Xerox Graphics Printer (XGP) at AI labs, it was painfully slow to use a typesetting typewriter, mechanical scissors, and sticky paste for each edit of text and figures. These tasks (traditionally performed by a publishing staff), in addition to initial editing, communicating with authors, writing articles and reviews, and publicizing the *Journal*, consumed 80- to 90-hour weeks, during which I was working mostly by myself. Some of us have been involved in founding companies; however, with no potential payoff in stock, founding and editing the *Journal* was an idealistic labor of love.

While editing the first issue of the *Journal*, I was very grateful for the occasional help of Marc LeBrun, a knowledgeable mathematician and programmer at CCRMA who had a good understanding of computer music. Production staff with a background in music, mathematics, computer science, electrical engineering, acoustics, and psychoacoustics were not available, especially at the level of wages offered by a nonprofit publisher. Eventually, I was able to hire Maria Kent, an intelligent individual with an invaluable background in typesetting, layout, and publishing. Ann Miya, a talented artist, was helpful in graphics design.

During production of the second issue of the *Journal*, I hired a bright graduate student from CCRMA for typesetting. In recognition of his deep musical knowledge, excellent writing and editing skill, and familiarity with computer music, I promoted John Strawn to Assistant Editor. It was helpful to be able to resolve problems as they arose, by discussing them with someone involved in our publication who understood our field. Later, when I was ready to return to full-time engineering work, I would have offered him the position of Editor had he been available. Understandably, his graduate degree program did not leave time for a full-time editing position. The time spent in editing typeset copy was further reduced when Renny (Reynold) Wiggins added his knowledge of computers to the production staff. Renny Wiggins later served as the Editor of *Dr. Dobb's Journal* for programmers.

Understanding Numerous Disciplines

James A. Moorer was the first author (other than myself) to provide an article, "Signal Processing Aspects of Computer Music—A Survey" (Moorer 1977), an excellent engineering overview for the first issue. The Institute of Electrical and Electronics Engineers (IEEE) kindly granted permission to publish his comprehensive article before it appeared in their journal.

To "bootstrap" readers who came from related disciplines, the challenging mix of subjects required tutorials and articles with introductory sections. A tutorial on how a computer makes music was provided by James A. Moorer and the editors (Moorer 1978). F. R. Moore provided an excellent introduction to the mathematics of signal processing, including the FFT (Moore 1978a, 1978b).

We had appreciated the classes in digital signal processing offered by James A. Moorer (and later by Julius Smith) at CCRMA, and we expected F. R. Moore's articles would serve as an introduction for subsequent articles on digital filtering (Smith 1985) and advanced applications of mathematics such as linear prediction (Cann 1979, 1980a, 1980b). The ability to create and manipulate timbre was hampered by the severely limited understanding of its nature. A series of introductory articles on timbre evolved from John Grey's valuable research in this area (Grey, Moorer, and Snell 1977; Grey, Moorer, and Strawn 1977). Articles on efficient yet musically significant algorithms that could run on inexpensive computers were also provided (Chowning 1977; LeBrun 1977; Saunders 1977).

Computers had been designed for data processing as opposed to real-time interactive stream processing. Therefore we published articles to address the design of real-time digital computers for music and synthesis (Snell 1977a; Moorer 1977; Moorer et al. 1979). Even something as simple as real-time multiplication was expensive and required numerous chips before the first issue of the *Journal* was published (Snell 1977b). I was so convinced by Chuck Hastings's introduction to high-speed design (Hastings 1978) that we changed the early design of Lucasfilm's first digital audio signal processor (ASP, also known as the SoundDroid) from Schottky transistor-transistor logic (TTL, used for most digital design at the time) to higher-performance emitter-coupled logic (ECL, used in supercomputers), which was also significantly less noisy than TTL. James A. Moorer (1979) also provided an excellent introduction to reverberation.

By the time the first issue of Volume 2 had been published, the focus and direction of the *Journal*

Figure 9. Volume 3, Number 1.

Figure 10. Volume 3, Number 2.

was established, high-quality articles were being submitted for publication, and the production process was finally functional. I wanted to focus on design and development of microelectronics and software for music (as opposed to editing a journal). To address the software revolution taking place, I invited Curtis Abbott to edit an issue of the *Journal* and write articles. Curtis started an interesting column called "Machine Tongues" (Abbott 1978a, 1978b, and 1978c). With hardware and software design better covered, I wanted to improve coverage of music composition in the *Journal*. Curtis Abbott introduced me to Curtis Roads around this time. With a background in software, a wide perspective on composition, and an interest in communication, Curtis Roads was the perfect Editor for this next phase of the *Journal*. John Strawn's excellent understanding of the *Journal* provided editorial continuity during the transition period.

Our high production standards and extensive typesetting of mathematics were challenging for PCC. MIT Press provided a timely offer to purchase the *Journal* from PCC, with production facilities more suited to academic journals. Although the editors did not receive money from the sale of the *Journal*, it found a stable home, ensuring its future. We are especially grateful to Curtis Roads for his ability and willingness to adapt to changing circumstances and politics while working on the *Journal*, which he continued to edit for so many years.

Books Derived from Early Years of *Computer Music Journal*

Curtis Roads, John Strawn, and I worked with authors to revise and update articles from the first three volumes of the *Journal*, along with new invited articles, for a two-volume book by MIT Press. Our large collection of articles was eventually published in three books: *Digital Audio Engineering* (Strawn 1985a), *Digital Audio Signal Processing* (Strawn 1985b), and *Foundations of Computer Music* (Roads and Strawn 1985) (see Tables 1–3). Before

Figure 11. Volume 3, Number 3.

Figure 12. Volume 3, Number 4.

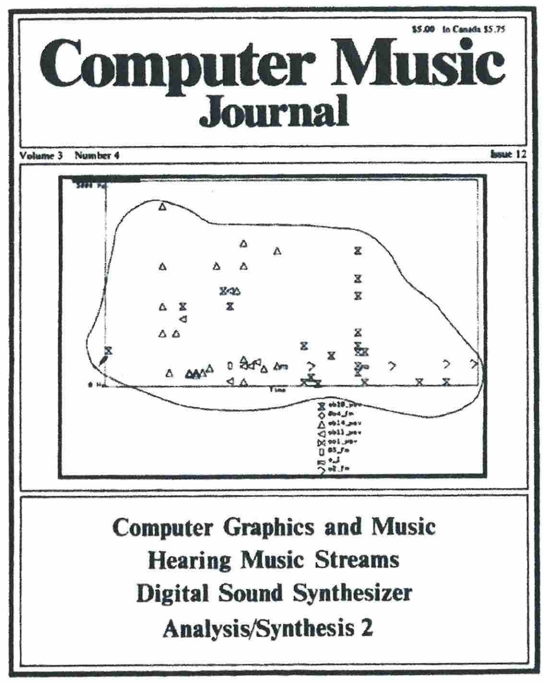


Table 1. Articles Published in *Digital Audio Engineering: An Anthology*

Article	*Author*
An Introduction to Digital Recording and Reproduction	J. F. McGill
Limitations on the Dynamic Range of Digitized Audio	R. Talambiras
Architectural Issues in the Design of the Systems Concepts Digital Synthesizer	P. Samson
The FRMBOX—A Modular Digital Music Synthesizer	F. R. Moore
The Lucasfilm Digital Audio Facility	J. A. Moorer

Table 2. Articles Published in *Digital Audio Signal Processing*

Article	*Author*
An Introduction to the Mathematics of Digital Signal Processing	F. R. Moore
An Introduction to Digital Filter Theory	J. O. Smith
Spiral Synthesis	T. L. Petersen
Signal Processing Aspects of Computer Music: A Survey	J. A. Moorer
An Introduction to the Phase Vocoder	J. W. Gordon and J. Strawn

Table 3. Articles Published in *Foundations of Computer Music*

Article	*Author*
The Synthesis of Complex Audio Spectra by Means of Frequency Modulation	J. Chowning
Trumpet Algorithms for Computer Composition	D. Morrill
Improved FM Audio Synthesis Methods for Real-Time Digital Music Generation	S. Saunders
The Simulation of Natural Instruments Tones Using Frequency Modulation with a Complex Modulating Wave	B. Schottstaedt
A Derivation of the Spectrum of FM with a Complex Modulating Wave	M. LeBrun
Organizational Techniques for C:M Ratios in Frequency Modulation	B. Truax
A Tutorial on Nonlinear Distortion or Waveshaping Synthesis	C. Roads
Brass-Tone Synthesis by Spectrum Evolution Matching with Nonlinear Functions	J. Beauchamp
An Analysis/Synthesis Tutorial	R. Cann
Granular Synthesis of Sound	C. Roads
PILE—A Language for Sound Synthesis	P. Berg
An Introduction to the SSSP Digital Synthesizer	W. Buxton, E. A. Fogels, G. Fedorkow, L. Sasaki, and K. C. Smith
The DMX-1000 Signal-Processing Computer	D. Wallraff
A Portable Digital Sound-Synthesis System	H. Alles
The 4B: A One-Card 64-Channel Digital Synthesizer	H. Alles and G. diGiugno
A 256-Channel Performer-Input Device	H. Alles
The 4C Machine	J. A. Moorer, A. Chauveau, C. Abbott, P. Eastty, and J. Lawson
Use of High-Speed Microprocessors for Digital Synthesis	J. F. Allouis
Design of a Digital Oscillator That Will Generate up to 256 Low-Distortion Sine Waves in Real-Time	J. Snell
Table Lookup Noise for Sinusoidal Digital-Oscillators	F. R. Moore
A Recipe for Homebrew ECL	C. Hastings
The Evolution of the SSSP Score-Editing Tools	W. Buxton, R. Sniderman, W. Reeves, S. Patel, and R. Baecker
Grammars as Representations for Music	C. Roads
The Use of Hierarchy and Instance in a Data Structure for Computer Music	W. Buxton, W. Reeves, R. Baecker, and L. Mezei
A Composer's Notes on the Development and Implementation of Software for a Digital Synthesizer	N. Rolnick
Automated Microprogramming for Digital Synthesizers	C. Abbott
A Software Approach to Interactive Processing of Musical Sound	C. Abbott
An Introduction to the PLAY Program	J. Chadabe and R. Meyers
A Microcomputer-Controlled Synthesis System for Live Performance	M. Bartlett
Considering Human Memory in Designing User Interfaces for Computer Music	O. Laske
An Interview with Gottfried Michael Koenig	C. Roads
Controlled Indeterminacy: A First Step Toward a Semistochastic Music Language	J. Myhill
Music for an Interactive Network of Microcomputers	J. Bischoff, R. Gold, and J. Horton
About This Reverberation Business	J. A. Moorer
Timbre Space as a Musical Control Structure	D. Wessel
Hearing Musical Streams	S. McAdams and A. Bregman

publication I released my third of this book project to John Strawn and Curtis Roads, so that I could focus on my work at Lucasfilm. I had been working for several years with James A. Moorer on the design and development of a large all-digital system with interactive consoles for real-time digital signal processing, sampling, synthesis, and multitrack recording and editing at Lucasfilm (Snell 1982; Moorer et al. 1985; Moorer et al. 1986). I felt a responsibility to the authors I had worked with over many years, and I was attached to our books that evolved from the *Journal* I had created. However, most of the editing was complete, and I knew John Strawn and Curtis Roads would do an excellent job of publishing this material. Because our collection of the edited articles was the essence of this early period, they are listed with their authors in the accompanying tables.

Figure 13. John Snell, Founder and original Editor of the Computer Music Journal, *with an all-digital mixing console he designed for Lucasfilm in the early 1980s (in which the assignment of knobs, sliders, switches, alphanumeric displays, and LEDs to any processing or synthesis parameter was fully programmable).*

Conclusion

Considering the articles shared by the authors in *Computer Music Journal* and derivative books over the last three decades, the *Pay It Forward* philosophy (see www.payitforwardfoundation.org) came abundantly to fruition, with seeds still growing. My own consulting practice (Timbre Engineering) sprouted from one of those seeds, nurtured by seven years of design engineering with James A. Moorer and others at Lucasfilm (Rubin 2005). Timbre Engineering has provided research, design, development, analysis, and reverse engineering of microelectronics (media processors, CPUs, routers, etc.) and software—as well as expert work on patents—with a focus on real-time interactive and high-bandwidth systems for audio and video processing, synthesis, and networking (Snell 1987, 1989a, 1989b, 1992, 1995).

I am grateful to the editors who maintained the quality of the *Journal* over several decades. I would especially like to thank to John Strawn and Curtis Roads for their superb editing of the *Journal*, as well as for the distinguished publication of our books. I am also very grateful to Stephen Travis Pope and Thom Blum for their skillful editing of the *Journal* over many selfless years, and to Douglas Keislar, who continues to do an excellent job of editing the *Journal*. I've especially appreciated his comments on this article. Each of the editors has contributed his perspective in selecting and inviting articles. With little financial incentive, editing is a labor of love. I would also like to thank Curtis Abbott (who deepened the *Journal*'s software foundation in the early years), Stephan Kaske, Anne Deane Berman, Chrysa Prestia, Keeril Makan, James Harley, Colby Leider, George Tzanetakis, Brett Terry, Margaret Cahill, and all the editorial staff and referees, who have significantly contributed to the quality of our *Journal*. We all appreciate the members of our Editorial Advisory Board over the years, as well as MIT Press. Ultimately, we are all grateful to the authors and reviewers, without whom the *Journal* would not exist.

References

Abbott, C. 1978a. "Machine Tongues I (The C Programming Language)." *Computer Music Journal* 2(2):4–5.
Abbott, C. 1978b. "Machine Tongues II (Programming)." *Computer Music Journal* 2(2):4–8.
Abbott, C. 1978c. "Machine Tongues III (Data Structures)." *Computer Music Journal* 2(2):7–9.
Cann, R. 1979. "An Analysis/Synthesis Tutorial, Part 1." *Computer Music Journal* 3(3):6–11.
Cann, R. 1980a. "An Analysis/Synthesis Tutorial, Part 2." *Computer Music Journal* 3(4):9–13.

Cann, R. 1980b. "An Analysis/Synthesis Tutorial, Part 3." *Computer Music Journal* 4(1):36–42.
Chowning, J. 1977. "The Synthesis of Complex Audio Spectra by Means of Frequency Modulation." *Computer Music Journal* 1(2):46–54.
Goldstein, J. 1976. *The Experience of Insight.* Boulder, Colorado: Shambala.
Goldstein, J., and J. Kornfield. 1977. *The Path of Insight Meditation.* Boulder, Colorado: Shambala.
Grey, J., J. A. Moorer, and J. Snell. 1977. "Lexicon of Analyzed Tones (Part I: A Violin Tone)." *Computer Music Journal* 1(2):39–45.
Grey, J., J. A. Moorer, and J. Strawn, 1977. "Lexicon of Analyzed Tones (Part II: Clarinet and Oboe Tones)." *Computer Music Journal* 1(3):12–29.
Hastings, C. 1978. "A Recipe for Homebrew ECL." *Computer Music Journal* 2(1):48–59.
Hyde, C. R. 1999. *Pay It Forward.* New York: Simon & Schuster.
LeBrun, M. 1977. "Notes on Microcomputer Music." *Computer Music Journal* 1(2):30–35.
Leder, M., director. 2000. *Pay It Forward.* Motion picture. Hollywood, California: Warner Brothers.
Moore, F. R. 1978a. "An Introduction to the Mathematics of Digital Signal Processing. Part I: Algebra, Trigonometry, and the Most Beautiful Formula in Mathematics." *Computer Music Journal* 2(1):38–47.
Moore, F. R. 1978b. "An Introduction to the Mathematics of Digital Signal Processing. Part II: Sampling, Transforms, and Digital Filtering." *Computer Music Journal* 2(2):38–60.
Moorer, James A. 1977. "Signal Processing Aspects of Computer Music—A Survey." *Computer Music Journal* 1(1):4–37.
Moorer, James A. 1978. "How Does a Computer Make Music?" *Computer Music Journal* 2(1):32–37.
Moorer, James A. 1979. "About this Reverberation Business." *Computer Music Journal* 3(2):13–28
Moorer, J. A., et al. 1979. "The 4C Machine." *Computer Music Journal* 3(3):16–24.
Moorer, J. A., J. Borish, and J. Snell. 1985. "A Gate-Array Multiplier for Digital Audio Processing." Preprint No. 2243 (D-8), 78th Audio Engineering Society Convention, New York.
Moorer, J. A., et al. 1986. "The Digital Audio Processing Station: A New Concept in Audio Post-Production." *Journal of the Audio Engineering Society* 34(6):454–463.
Roads, C., and J. Strawn, eds. 1985. *Foundations of Computer Music.* Cambridge, Massachusetts: MIT Press.
Rubin, M. 2005. *droidMAKER: George Lucas and the Digital Revolution.* Gainesville, Florida: Triad.
Saunders, S. 1977 "Improved FM Audio Synthesis Methods for Real-Time Digital Music Generation." *Computer Music Journal* 1(1):53–55.
Smith, J. O. 1985."Fundamentals of Digital Filter Theory." *Computer Music Journal* 9(3):13–23.
Snell, J. 1976. "Computer Music Bibliography." *DDJ (Dr. Dobb's Journal of Computer Calisthenics & Orthodontia)* 1(7):33–35.
Snell, J. 1977a. "Design of a Digital Oscillator Which Will Generate up to 256 Low-Distortion Sine Waves in Real Time." *Computer Music Journal* 1(2):4–25.
Snell, J. 1977b. "High Speed Multiplication." *Computer Music Journal* 1(1):38–45.
Snell, J. 1982. "The Lucasfilm Real-Time Console for Recording Studios and Performance of Computer Music." *Computer Music Journal* 6(3):33–45.
Snell, J. M. 1987. "Professional Real-Time Signal Processor for Synthesis, Sampling, Mixing, and Recording." PreprintNo. 2508 (M-4), 83rd Audio Engineering Society Convention, New York.
Snell, J. M. 1989a. "Multiprocessor DSP Architectures and Implications for Software." Paper presented at the Audio Engineering Society 7th International Conference, 14–17 May, New York.
Snell, J. M. 1989b. "Expandable Interactive Real-time Multiprocessor DSP." *Proceedings of the IEEE ASSP Workshop on Applications of Signal Processing to Audio and Acoustics.* New York: IEEE Press.
Snell, J. 1992. "RISC vs DSP in Embedded Applications." *Computer Design.* Westford, Massachusetts: April:65.
Snell, J. 1995. *Multiprocessor Architectures and Design Techniques for Media Signal Processing and Synthesis 1991–1995.* San Geronimo, California: Timbre Engineering.
Strawn, J., ed. 1985a. *Digital Audio Engineering: An Anthology.* Madison, Wisconsin: A-R Editions.
Strawn, J., ed. 1985b. *Digital Audio Signal Processing: An Anthology.* Los Altos, California: William Kaufmann.
Suzuki, S. 1970. *Zen Mind, Beginner's Mind.* New York & Tokyo: Weatherhill.