THE CENTER FOR NEW MUSIC AND AUDIO TECHNOLOGIES

David Wessel, Richard Felciano, Adrian Freed, and John Wawrzynek

CNMAT
Department of Music
University of California at Berkeley
Berkeley, California 94720

Telephone: 1-415-643-9990
e-mail: wessel@violet.Berkeley.EDU

ABSTRACT

The University of California, Berkeley has established a new facility for musical research, composition, performance, and education. The Center for New Music and Audio Technologies, CNMAT, provides a common ground for music and audio related research activities in the Departments of Music, Electrical Engineering and Computer Sciences (EECS), Psychology, Linguistics, and Architecture. CNMAT is located at 1750 Arch Street, Berkeley. Upon completion of the building renovations in 1993, it will provide an environment consisting of music and audio workstations, acoustically isolated studios, and an experimental performance space. CNMAT specific projects include computer architectures for sound synthesis and processing, research on music perception and cognition, the development of new media resources for music scholarship and education, and the development of software and controllers for live performance computer music.

We hesitate to present work in progress but like proud parents we are optimistic about the promise of this newborn facility.

Conceived by composer Richard Felciano, the Center for New Music and Audio Technologies was established to link those disciplines on the Berkeley campus doing research or creative work in sound. Its mission is musical in the broad sense with research and development efforts focused on composition, performance, music scholarship, and education. Highly interdisciplinary in character, CNMAT has faculty positions associated with both the Departments of Music and Electrical Engineering and Computer Sciences and has strong ties to the Departments of Psychology, Linguistics, and Architecture.

CNMAT’s research efforts are oriented around four interconnected themes: the first involves new hardware architectures, the second concerns the perceptual and cognitive aspects of music, the third explores new media for music scholarship and education, and the fourth is oriented towards the technical and musical problems of live computer music performance.

VLSI Architectures for Audio Signal Processing

John Wawrzynek directs CNMAT’s chip design efforts and continues his work on custom architectures for music synthesis previously carried out at Caltech [Wawrzynek 1989; Wawrzynek & Mead, 1985]. The objective is to explore specialized VLSI architectures for a variety of musical

John Wawrzynek is an Assistant Professor of Electrical Engineering and Computer Sciences; Adrian Freed directs CNMAT’s software research efforts; Richard Felciano is the Center’s General & Artistic Director; David Wessel is its Research Director. Felciano and Wessel are Professors in the Department of Music.
and audio applications. While generality is a desired goal for music chips, it often imposes a performance penalty. We feel that by focusing on particular classes of algorithms our designs will yield higher performance than could be achieved otherwise. Current emphasis is on multiprocessor systems composed of diverse architectures.

One of the VLSI projects that has reached some maturity in its design is called MIMIC for Memory Intensive Music Integrated Circuit [Wawrzynek & von Eicken, 1989]. The earlier generation of Caltech UPE's mainly addressed the arithmetic computation needs of physically based synthesis models. The insights gained with these systems demonstrate the feasibility of this computational approach to physical modeling but also clearly indicate that single chip systems cannot offer sufficient performance for ensembles of such instrument models. Furthermore, the UPE's memoryless architecture limited its applications to those not involving delay lines and tables. To overcome these problems a new board-level architecture has been proposed. The architecture relies heavily on the use of memory, both within the custom processing chips and at the board level where commercial memory parts are used. The custom chip combines arithmetic, network management, and memory functions to supply interpolated table values. We are currently evaluating the design through simulation and with pilot implementations of synthesis models on the 56001-based digital signal multiprocessor [Barriere, Freed, Bajsnee, and Baudot 1989].

Wawrzynek regularly gives courses in VLSI system design and computer architecture fundamentals as well as specialized architectures for audio signal processing. Students realize designs and see them through to fabrication.

Perceptual and Cognitive Foundations of Music

This project area is under the direction of David Wessel and is concerned with the development of music theory rooted in perceptual and cognitive psychology. While music is an important and revealing subject area for the study of perception and cognition, studies of music perception have had a debatable and certainly less acknowledged impact on compositional practice. We believe that one of the main reasons for this apparent lack of influence is that many of the significant results from perceptual and cognitive research on music have not found their way into the composers' toolkit, either as concepts or as functioning software. In an effort to correct this situation, we are embedding perceptually based representations of musical material in our compositional environments [Wessel 1985; Wessel, Bristow, & Settle 1987].

CNMAT's emphasis on musical perception and cognition is enhanced by its association with Berkeley's Department of Psychology where Professor Ervin Hafer has an active hearing research group. Music perception will be the subject of the Berkeley hearing research seminar during the spring semester of 1989.

Wessel gives a course on the perceptual and cognitive foundations of music each spring semester in the Department of Music.

New Media Resources for Music Scholarship and Education

Under the direction of Adrian Freed, this project area explores the potential of hypermedia when music is the subject. A more detailed presentation of this work applied to the history of the country blues can be found in another paper in these proceedings [Freed 89]. One of the goals is to develop, with readily available and affordable components, workstations that serve music scholars. Such systems would provide rapid access to large quantities of suitably indexed high-fidelity audio materials, data derived from traditional music notation, text materials, and images. The establishment and use of links among these diverse materials is central to the working environment. We feel that providing immediate and indexed access to reference materials such as recorded performances and scores will have an impact upon musical studies analogous to the impact of photography on the study of the history of art.
While the country blues project demonstrates the potential of our new media resources work for historical studies, another project is aimed more directly at the subject matter of computer music. Sam Pointer, a graduate student in Electrical Engineering and Computer Sciences, is developing a hypermedia digital signal processing course for musicians that exploits the NeXT machine. Here Mathematica, an interactive symbolic mathematics package [Wolfram 1988], the NeXT Interface Builder, and the digital audio capabilities of the machine are combined to permit interaction with the formal mathematical aspects of DSP, their graphical representation, and sound examples.

In a related project, Ben Brinner, an ethnomusicologist and new addition to the Music Faculty, with the assistance of Alain Goye, a computer scientist visiting CNMAT from ENST in Paris, is developing what we have come to call the Ethnomusicologist’s Workbench. The goal is to provide an environment that aids in the exploration and characterization of recorded materials. This environment consists of tools for selecting, playing, viewing, editing, indexing, transcribing, and linking segments of the recorded performance. These tools are complemented by a signal processing library with procedures for pitch extraction, temporal segmentation, and the separation of simultaneously sounding sources.

Contexts and Systems for Live Performance

Given CNMAT’s emphasis on the development of real-time synthesis hardware it is obligatory to research and develop the software and controller elements essential to live performance systems. The 56001-based digital signal multiprocessor interfaced to a Macintosh II currently provides the vehicle for activities here. One key research issue that ties in closely with the VLSI and perception projects is the exploration of musically viable control structures for physically based synthesis models. To get a better fix on the problems of compositional and live performance control we are exploring sets of physical models and their parameterization and control.

Additional Cross-Disciplinary Activity

Under the guidance of Professors Marc Treib of Architecture and Richard Felciano, graduate student architects and composers are collaborating on the design on a hypothetical extension of CNMAT’s present building down the hill overlooking the Golden Gate. This is a prelude to the establishment of a course dealing specifically with design needs of buildings constructed for musical purposes, further strengthening the offerings of Berkeley’s School of Architecture, and to CNMAT’s eventual development of software to assist architects in dealing with acoustical problems of building design.

In addition, a cross-disciplinary group of undergraduate student mentors, one from each of the Center’s five participating departments, has been established under the direct supervision of the Center’s Director.

Providing a Musical Focus to Research

At CNMAT we have adopted a strategy that will bring musical issues, be they compositional, theoretical, or performance-oriented, into the research and development process at a very early stage. While this may mean a bit of rough going for some because of the lack of stability in the hardware and software environments, we feel that there are special advantages to vigorous and early involvement of musicians in technical developments. To help assure early mutual influence, we insist that compositional, performance, and other musical prototyping projects be involved from the beginning.

The Building and Facilities

CNMAT is located on the north edge of the campus in McEnerney Hall at 1750 Arch Street, a well known address in music circles that provided a home to a lively concert series, the Arch Ensemble, and 1750 Arch Records from the mid-seventies through the early eighties. UC Berkeley purchased this elegant, Spanish-style villa and appointed William Gratiot as the project architect. Gratiot was the architect responsible for the recent renovations at Stanford’s CCRMA. Randy Sparks of RLS Acoustics is the acoustical consultant.
At this time, November 1989, we are operating out of McEnerney Hall in a somewhat rustic fashion. The current equipment configuration consists of Macintosh and NeXT based workstations, a digital signal multiprocessor based on eight Motorola 56001's [Barriere, Freed, Baisnee, and Baudot 1989], and a collection of audio and related commercial gear.

The renovations will hopefully be completed during spring of 1990 after which the facility will be more thoroughly outfitted.

Acknowledgements

We would like to express our gratitude to those who have supported and encouraged us to make CNMAT a reality. Special thanks go to Provost Leonard V. Kuhi and Vice Chancellor Roderic B. Park, to Professors Bonnie Wade and Philip Brett, past and present chairmen of the Department of Music, and Professor Alvin Despain formerly of U C Berkeley's Department of Electrical Engineering and Computer Sciences and now Chairman of the Department of Computer Science at the University of Southern California. Thanks also to John Chowning, Patte Wood, and Chris Chafe of CCRMA who have been especially helpful with advice. We are also grateful to a number of other institutions and individuals for the ideas and the functioning software they have supplied.

References


339