Center for Computer Research in Music and Acoustics

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Overview 1982 – 1983

Introduction

The Stanford Center for Computer Research in Music and Acoustics (CCRMA) is an interdisciplinary facility and major resource where composers and researchers work together using the computer as a new musical and artistic medium, and as a research tool.

Areas of ongoing research and development at CCRMA have included: digital synthesis, signal processing, psychoacoustics, interactive composition, graphics, digital recording and editing, and musical intelligence.

Initial funding for the Center was received in 1975 with a joint grant from the National Science Foundation and the National Endowment for the Arts. This funding supported initial equipment acquisition and research support for a small research staff which included faculty members John Chowning and Leland Smith and research associates John Grey, James A. Moorer and Loren Rush.

CCRMA at this time shared a facility with the Stanford Artificial Intelligence Laboratory. In November 1979, the Artificial Intelligence Laboratory moved to a new facility in Margaret Jacks Hall on the Stanford campus. CCRMA separated from the Artificial Intelligence Laboratory and established its own facility which consisted of: a Foonly F2 central processor with 256K of memory (emulating a DEC PDP-10), a 16-channel Grinnell display system, 12 high-resolution video terminals, a digital synthesizer/processor called the "Samson Box," 4 16-bit D/A converters (the "DAC"), 2 14-bit A/D converters (the "ADC"), and several listening stations (amplifiers, level control and speakers). Analog audio equipment included a Scully 4-track half-inch tape recorder, 2 Sony 4-channel tape recorders, a Yamaha 4-channel mixer, 4 channels of amplifiers and dividing networks and Yamaha custom-made speakers.

Additional funding for the Center has been received from the California Arts Council, the National Endowment for the Arts "Centers for New Music Resources" program, the National Science Foundation, the Rockefeller Foundation, the System Development Foundation, Yamaha, and from private gifts.

These grants have provided technical support, research support, support for visiting composers, and additional equipment.

An Interactive Resource

CCRMA has become one of the major centers for computer music in the United States. Other centers of computer music include IRCAM, Paris; CME, UC San Diego; MIT; Colgate University; and Northwestern.

Currently there are 56 active users at CCRMA including: 18 faculty, staff, and research associates, 21 graduate students, and 15 foreign and domestic guest composers/researchers. Activities at CCRMA include teaching, research, composition, interactive performance, workshops, presentations, concerts, and recordings.

CCRMA is based upon the use of a powerful interactive computer system for purposes of music composition, synthesis, and research, by staff, students, and invited researchers and composers. As a musical instrument, the computer system is possibly the most flexible of all instruments. To speak of it as a conventional musical instrument, however, is somewhat misleading because the system is capable of simultaneously producing a large number of independent voices having complex timbral characteristics. It is much more general than a conventional musical instrument in that it can generate any sound that can be produced by loudspeakers, modify and transform real sounds entered into the system by means of microphone and digital-to-analog converters, remember and modify articulated musical input, and simulate the location and movement of sounds in a variety of illusory reverberant spaces. Equally important, the facility is capable of serving a number of composers and researchers simultaneously, providing for each a direct control over the medium to a degree which was never before possible.

In addition to the Stanford community, CCRMA serves as a resource for visiting composers and researchers from throughout the world. The results of this interaction are presented to the public through concerts, demonstrations and research publications.

CCRMA conducts a five-week intensive workshop in Computer Music each summer. This workshop has an enrollment of twenty composers from the U.S. and abroad and has been the impetus for other new computer music facilities. Outside of the workshop, we also make the facility available to a limited number of visiting composers for extended periods of time to produce major compositions.

Several public concerts are given each year with an audience of approximately 2,000 people per concert and approximately nine informal demonstrations are given at the center with an attendance of between 30 to 50 people. Members of the CCRMA staff also give invited lectures and presentations at various institutions and colloquia in the U.S. and abroad. Works composed at CCRMA are widely represented in concerts, competitions, and radio broadcasts. Over 40 compositions have been realized at CCRMA. Several of these compositions have received major prizes including the prestigious Bourges prize in electronic music.

The Center has close associations and has served as the prototype or impetus for other computer music facilities including Columbia, Colgate, Clark, Carnegie-Mellon, Michigan State, George Lucas' Marin facility, Queen's Univ. and the University of California at San Diego. The association with IRCAM, Paris, the institute directed by Pierre Boulez, has developed as proposed by Boulez in 1974 in that the two centers have a strong interaction through the exchange of research ideas, results and personnel.

The following sections summarize the existing research facility, and recent CCRMA activities.

Research Facility

The CCRMA research facility is currently housed in the D. C. Power Laboratory Building owned by Stanford University. Plans are underway for CCRMA to move into "the Knoll" on the Stanford campus in September 1984. CCRMA is currently working with the university planning office, the architect firm of Bowers, Richert and Gratiot, and acoustical consultant George Augsperger to specify and design research spaces for CCRMA at the Knoll. A fund-raising effort will be initiated to raise money to build the special studio spaces CCRMA will need in this new facility. The projected facility will include a classroom, a large experimental demo space with control room/studio, a recording studio with control room, psychoacoustic experiment studio, and several areas for workstations and terminals.

With recent upgrades, the CCRMA computer facility currently consists of the following hardware resources:

Central processor: a Foonly F4 mainframe computer running the WAITS operating system for the bulk of CCRMA's timesharing needs.

Graphics terminals: There are 16 terminals distributed throughout the facility. The image on each terminal is produced by a Grinnell display processor, and provides high-bandwidth text output and graphics at a resolution of 512×512 pixels.

Disk and tape storage: The CCRMA WAITS system has 900 Mbytes of online storage for system and user files. There is an additional disk drive dedicated to user disk packs which provides 300 Mbytes of removable storage. Two 1600 bpi tape drives are used for archival storage of system and user files, and for exchange of information with other sites.

Graphics hardcopy: There are three graphics output devices. Most hardcopy is printed on an Imagen LBP-10 laser printer, which prints letter-quality output at a resolution of 240 points per inch on plain paper. Music manuscripts, logic drawings, and other graphics are printed on a Versatec 8222 electrostatic plotter, which can make plots up to 22" wide at a resolution of 200 points per inch. A Printronix printer-plotter rounds out the group; in addition to standard line printer capabilities, it can plot on 11" $\times$ 14" line printer paper (albeit slowly) at a resolution of 70 points per inch.

Real-time synthesis: The bulk of all sound synthesis is done on the Systems Concepts Digital Synthesizer (the "Samson Box"). The Samson Box was designed by Peter Samson and built by Systems Concepts in San Francisco. It is an all-digital synthesizer with provision for processing digitized data from the outside world as well as for synthesis. Up to 256 basic signals can be generated, each with individually "ramped" amplitude and frequency envelopes; the waveforms can be configured for FM modulation or summed into any of 64 "sum-memory" locations. There are 128 "modifiers" used for mixing, filtering, noise generation, and other more specialized functions. As digital filters, they can provide up to 256 poles and/or zeros. There are 32 delay units for reverberation, and we have 48 Kwords of delay memory which can be arbitrarily partitioned among the delay units. Thus, the three major synthesis categories plus facilities for sound modification are well supported in the Samson box.

Listening stations: There are six "listening stations" distributed through the facility. At each station, there are one or more graphics terminals, and a stereo or quad speaker/amplifier system. Audio signals from the Samson Box or other audio sources are routed to any of the listening stations through an audio switch controlled by the central computer.

Audio switch: We have installed two audio switch systems built by Concert Music Design. One of the systems is dedicated to our "listening room," and handles the interconnection of the audio gear there. A personal computer runs a control program to handle the patches. This greatly simplifies the usual complexities of interconnecting many pieces of audio equipment. User-specified "patches" may be stored

on a disk file and recalled for subsequent sessions; this is an important feature for a resource that must be used by different people.

Another audio switch system controls the routing of sound to various offices and listening spaces around the laboratory. This makes it possible to listen to the output of the Systems Concepts digital synthesizer from any office. Other sources of sound will be added to the system as they become available. The routing of this audio switch is controlled by the Foonly computer. This makes it possible for a user to connect any channel (including silence) to the speakers in his or her office.

Listening room: One large room is acoustically treated and is set up for monitoring and recording. It contains an array of two- and four-track analog tape decks, a two-channel digital recorder, a four-channel bi-amplified sound system, mixing facilities, and a computer-controlled patching system. A small stage area at one end of the listening room provides a place for live performances, public demos, and recording.

Outside access: CCRMA has four medium-speed dialup lines (1200/300 baud) for access to the computer system. We own four Datamedia terminals, which are distributed among the CCRMA researchers and staff.

The CCRMA computing system provides a rich programming environment. The primary high-level programming language used is SAIL, a derivative of Algol, whose extensions include record structures, interrupt-level processing and extensive macro facilities.

Numerous libraries and user programs exist for reading and writing sound files, signal processing, and device-independent graphics.

Research

Recognizing the recent advances in computing machinery, operating systems, and languages, CCRMA is expanding and reorganizing its computing environment. This reorganization is embodied in the development of 68000-based computer music workstations and and Lisp machines in a networked environment. These workstations are envisioned as the next generation in computer music. They will be small, portable, and affordable to individual composers and schools, thus making the use of computers in music available to a much larger number of people.

Members of the technical staff at CCRMA have participated in discussions with the computer music groups at MIT, UCSD, Northwestern, Lucasfilm, and IRCAM to get a sense of what the technical directions of these groups are likely to be and what directions the music workstation project should take. The hope is to open a technical dialogue which will promote more "synergy" between the groups. With the profuse advances in signal processing techniques and computing systems, this is the only way to prevent vast amounts of duplicated efforts at these different sites. Discussions have also taken place with Carver Meade and John Wawrzynek of the California Institute of Technology regarding progress on the VLSI synthesis chip.

Other areas of research at CCRMA include interactive composition, signal processing, psychoacoustics and musical acoustics, digital editing and recording, synthesis, music manuscripting, and musical intelligence. A description of ongoing research at CCRMA is available in *Recent Research at CCRMA*.

Publications

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Chowning, John, "Meet the Composer", Yale University, Nov. 1982.

Chowning, John, Lecture and presentation, Harvard University, Nov. 1982.

Chowning, John, "Celebrating the Computer", presentation, University of the Pacific, Jan. 1983.

Chowning, John, "Computers and Music: A Rich Interaction", lecture and presentation, Stanford University, Feb. 1983.

Chowning, John, "An Evening of Computer Music", presentation, New York Academy of Sciences Symposium "The Scientific, Intellectual and Social Impact of the Computer", Apr. 1983.

Chowning, John, "The Newest Musical Instrument: The Computer", lecture and performance, Arts and Technology Symposium, UC Santa Cruz, May 1983.

Chowning, John, Lecture and presentation, American Academy of Arts and Science Meeting, Detroit, May 1983.

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Rush, Loren, C. Chafe, B. Mont-Reynaud, and A. Schloss, "Machine Recognition of Musical Constructs" presentation, Center for Music Experiment, UCSD.

Schloss, A. and B. Mont-Reynaud, "Machine Recognition of Musical Constructs", paper presented, ICMC, Venice, Italy, Oct 1982.

Sheeline, Christopher, "Reverberation Modelling and Spatial Cues for Computer Music", paper presented, ICMC, Venice, Italy, Oct 1982.

Smith, Julius, "Synthesis of Bowed Strings", paper presented, ICMC, Venice, Italy, Oct 1982.

Strawn, John, "Research on Timbre and Musical Contexts at CCRMA", paper presented, ICMC, Venice, Italy, Oct 1982.

Major Works completed 1982-1983

Chris Chafe completed *In a Word* for cello and tape. The accompanying computer part uses an adaptation of John Chowning's frequency modulation technique for generating sung vowels. The intent was to create vocal and orchestra-like sounds changing in size which the cello can travel through. Pops, clicks, wheezes and other fast phenomena are peppered over the timbres rather than simulations of natural consonants. Fast rhythmic material is based on repetition of patterns of these, creating rhyme schemes with the unintelligible voices. Slow material is a free-floating vocalise. The cellist's job is to track several cues and fit his or her timings to the rigid timing of the accompaniment. *In a Word* was premiered at Frost Amphitheater in July of 1982 and performed at the San Francisco Museum of Modern Art in April 1983.

The composition *Silicon Valley Breakdown* by David Jaffe was completed in July 1982. This is a spatial-antiphonal piece, twenty minutes in length, scored for four widely-separated loud speakers. The piece uses entirely synthetic plucked string sounds, developed by the composer along with Julius Smith. *Silicon Valley Breakdown* has been played in America at Stanford, Boston, and the Cal-Arts Contemporary Music Festival, and in Europe at the Venice Biennale, Padova, Rome, and the Berlin Festival. This piece was awarded second prize in the 1982 NewComp computer music contest.

Jan Mattox completed *Shaman, Part II* in August, 1982. *Shaman* is a four-part musical theatre piece for percussionist, belly dancer, bassist, and computer-processed and -synthesized sound. For Part II: "Song from the Center of the Earth," FM synthesis techniques were used to combine characteristics of both the female soprano and the Arabic flute, creating the surrealistic and passionate voice of the Primordial Goddess (dancer Rachel Dutton).

Bill Schottstaedt completed a large five-movement work *Colony* in March 1983. Its orchestra consists of FM violins, bells, voices, birds, frogs, and insects. The animal sounds were synthesized from data in the spectrograms published in several bird guides.

Bill Susman completed *Cityscape* for computer-generated quadrophonic sound and solo piano. The composition may be performed with or without the piano. For the premiere performance, April 11, 1983, at the San

Francisco Museum of Modern Art, the composer performed the piano part. At a subsequent performance, on August 6, 1983, at CCRMA, *Cityscape* was performed without the piano part.

CCRMA Recordings

The Digital Domain: a Demonstration, a Compact Disc of music from CCRMA. Produced by Loren Rush, Janis Mattox and Elliot Mazer as a demonstration of the capabilities of current digital audio. Completed in August, 1983 for Warner Special Products. Released in January, 1984 by Electra.

Computer Music from CCRMA, stereo cassette tape containing pieces by John Chowning, David Jaffe, Chris Chafe, Bill Schottstaedt, Jonathan Berger, Andy Schloss and James A. Moorer. Produced by Janis Mattox. Released in November, 1983.

A series of recordings, partially supported by NEA and System Development Foundation of works by American composers realized at CCRMA. The records will be released by 1750 Arch Records, Berkeley, The planned records are:

1)	Michael McNabb:	*Dreamsong, Love in the Asylum, Mars Music*;
		to be released February 1, 1984
2)	Bill Schottstaedt:	*Colony*;
		in progress
3)	David Jaffe:	*Silicon Valley Breakdown*;
	Chris Chafe:	*In A Word* (for cello and computer sound);
		Solera;
		in progress

Other Recordings

Chowning, Excerpts from *Stria*, Pierre Boulez, Materiau et Invention, cassette tape, Radio France/IRCAM, 1982.

Chowning, Excerpts from *Stria*, IRCAM, a portrait, stereo phonograph record, Centre Georges Pompidou, Paris, 1983.

Schloss, *Cuban Danzon*, recorded by Andy Schloss — Folkways FE4066; released in 1981.

Other Activities at CCRMA

Major Performances

CCRMA presented several major concerts of computer music in the San Francisco bay area and many compositions were represented in concerts in the U. S. and in Europe.

In March 1982 and April 1983, the San Francisco Contemporary Music Players presented concerts of music from CCRMA at the San Francisco Museum of Modern Art.

CCRMA presented its annual festival of computer music at Frost Amphitheater on July 16 and 17, 1982. Compositions included the premieres of David Jaffe's *Silicon Valley Breakdown* and Chris Chafe's *In a*

Word. Also participating in the festival were composer Dexter Morrill, French composer Jean-Claude Risset, Canadian composer Bruce Pennycook and soprano, Neva Pilgrim.

In October 1982, compositions realized at CCRMA were well represented at the Venice Biennale as part of the International Conference of Computer Music. Performances included:

Jonathan Berger	*To the Lost History of Hope*
David Jaffe	*Silicon Valley Breakdown*
Thierry Lancino	*Static Arches*
Michael McNabb	*Love in the Asylum*
Andy Schloss	*Towers of Hanoi*
Bill Schottstaedt	*Daily Life Among the Phrygians*
Tim Souster	*Driftwood Cortege.*

The July 1983 CCRMA computer music festival included the premier of Bill Schottstaedt's five-movement work *Colony.*

Other performances of CCRMA compositions included concerts and broadcasts in Cambridge, MA; New York, NY; San Antonio, TX; Pittsburgh, PA; New Haven, CT; Boston, MA; Los Angeles, CA; Vancouver, BC; Berlin; Paris, FR; Bourges, FR; Basel, SW; Cologne, WG; Hannover, WG; London, GB; Rome, IT; Padua, IT; Helsinki, FI; Holland; Stockholm, Sweden; Tokyo, JA; and Warsaw, PO.

Awards

Jonathan Berger, Chris Chafe, David Jaffe, and Loren Rush all received composer's fellowships from the National Endowment for the Arts.

Jonathan Berger is a 1983 recipient of the American Society of Composers, Authors, and Publishers (ASCAP) Prize for young composers for his work *The Fires of the Night* for three celli and orchestra. The work employed an algorithm developed at CCRMA that generated note lists and linked into Leland Smith's MS manuscript program for graphic output.

Chris Chafe's *Solera,* Thierry Lancino's *Static Arches* and Michael McNabb's *Love in the Asylum* all tied for 2nd Prize in the annual Concours de Bourges 1982.

David Jaffe's *Silicon Valley Breakdown* won 2nd Prize in the 1983 NewComp contest.

Workshops and Visiting Composers 1982-83

CCRMA held its annual computer music workshop as part of the Stanford University summer session in June and July. The average attendance of the five-week workshop was 20 composers and researchers from all over the U.S.

A special workshop for German composers was sponsored by the Goethe Institut and held at CCRMA in August 1983. The workshop was taught by Johannes Goebel, John Chowning, Chris Chafe, David Jaffe, John Strawn, and John Gordon and was attended by composers: Helmut W. Erdmann, Gerhard Staebler, and Michael Barolsky. A concert was presented of computer music from CCRMA and works by visiting German composers in conjunction with the workshop.

Visiting composers and researchers at CCRMA during 1982 and 1983 included:

Johannes Goebel	composer from Germany (summer 1983)
Conrad Cummings	composer from IRCAM, Paris (summer 1983)
Jean-Pierre Dautricourt	composer and physicist from France (one year beginning Sept 1983)
Gerard Grisey	French composer, on the faculty at Berkeley (one year beginning Sept 1983)
Laurie Hollander	composer from New York (Sept 18 - Sept 30)
Thierry Lancino	French composer from IRCAM (fall 83, spring 84)
Elzbieta Sikora	Polish composer from Warsaw, now living in France (Sept - Dec 83 possibly longer)