A Proposal to the Hewlett Packard Company for an Equipment Grant

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CCRMA has served as an international resource for computer music research and composition for more than twenty years. Some of the unique achievements originating at CCRMA have had a profound effect on education, research, the music industry, and the evolution of 20th century music composition:

- Expertise in the technology of sound synthesis, acoustics, signal processing, and psychoacoustics has resulted in the development of an extraordinarily powerful family of synthesis devices which now serve as tools in education, music performance, composition, and research.

- Work in the area of computer graphic music score representation provides the musician-composer with a flexible new means of music printing which will revolutionize the music publishing industry.

- Research in automatic music transcription from sound sources involving signal processing, artificial intelligence and expert systems will prove to be a powerful tool in music education and in the archiving and transcription of the vast amount of recorded ethnic music.

- Digital recordings of the world's great operatic voices will serve as the basis for analysis and computer modelling of this most complex of all musical sources. As part of general research in physical modelling of musical instruments, the model of the singing voice depends upon CCRMA's new digital recording studio, access to the great voices through the San Francisco Opera, new digital signal processing techniques being developed at CCRMA, and technological support from industry.

These are some of the diverse areas of research at CCRMA which attract (and profit from) students from disciplines as diverse as aero-astronautics, electrical engineering, computer science, psychology, speech and hearing sciences, and of course, music. Students graduated from our program continue to work in related fields in a variety of contexts in industry and education. Recent graduates are currently employed at Lucasfilm, Intellicorp, Fairchild/Schlumberger, Next Inc., Opcode, IRCAM Paris and at a number of American universities including Stanford, Yale, Brown, Colgate, and UCSD.

With increasing knowledge in the area of computer music and signal processing, new equipment is required to effectively teach students and pursue research at CCRMA. Signal analyzers would find wide use in teaching and research, but especially in the teaching of introductory courses where the concepts of time vs. frequency domain, dynamic spectra, and timbral analysis can be easily and effectively demonstrated.

The computer workstations we are requesting from Hewlett Packard are needed as tools for teaching and research. The instruction program in digital signal processing will benefit from the up-to-date computing environment provided by these machines. Standard signal processing packages will become available, which, when combined with digitizing and graphics capabilities, will create high-performance acoustics and signal processing "workbenches." We have worked with Wendell Fields and Karen Sherriff in discussing our needs and developing this request.

Two specific research areas will make use of the equipment. An acoustics workbench that is coupled with digital recording studio equipment is needed for the project in physical modelling of instruments and voice. VME bus connections plus large capacity disk storage as specified will provide these capabilities. Master instrumentalists and singers will be directly recorded at the CCRMA studios to provide a large base of performances that can be analyzed and modelled.

The workstations are to be applied in a second area of research interest, artificial intelligence. Demonstrated AI capabilities, to date, have included the automatic transcription of musical performances, the disentangling of multiple acoustic sources within a single channel and the recognition of higher level musical patterns. Future accomplishments will depend on the availibilty of integrated systems with the above workbench properties, as well as Common Lisp, object-oriented programming environments (HP's Common Objects) and network functions that support distributed processing.

We believe that such equipment is critical to the overall quality of our teaching and research activities. We therefore make this request to Hewlett Packard for the equipment listed.

Attached: list of equipment requested
list of courses taught and recent dissertations
overview of research and list of publications

List of equipment.

The list is broken into two pages. The equipment below is needed for teaching demonstrations and laboratory maintenance. The following sheet lists computer equipment to be used for teaching and research.

(prices from the 1986 Hewlett Packard Catalog)

Quantity	Description	Part No.		Unit	Total
1	Dynamic Signal Analyzer	HP 3562A with opt. 907	[note 1]	23,975	23,975
1	Dynamic Signal Analyzer	HP 3561A	[note 1]	10,300	10,300
1	Graphics Plotter	HP 7550A	[note 1]	3,900	3,900
1	Distortion Measurement Set	HP 339A with opt. 001	[note 2]	2,825	2,825
1	Function Generator	HP 3314A	[note 2]	4,200	4,200
1	Multimeter	HP 3468A	[note 2]	750	750
1	Basic Universal Counter	HP 5314A	[note 2]	550	550
1	AC Voltmeter	HP 400F	[note 2]	1,090	1,090
				Total:	$43,690

[note 1] For use in classroom teaching and music composition

[note 2] Required for maintenance and repair of analog recorders

(prices from the June, 1986 Series 9300 Catalog, n/a = info not available)

Quantity	Description	Part No.		Unit	Total
6	Model 9320CX Workstations	HP 98586A	[note 1]	34,900	209,400
18	RAM Boards for full memory	HP 98257A	[note 1]	1,450	26,100
6	130 Mbyte Winchester Disk	Falstaff	[note 1]	n/a	n/a
6	1/4" Cartridge-tape Backup	HP 9144A	[note 1]	3,500	21,000
6	(second) Color Display	HP 98782A	[note 1]	6,050	36,300
6	VMEbus interface	HP 98646A	[note 2]	1,272	7,632
6	ADC interface	HP 98640A with opt. 630	[note 2]	990	5,940
6	Quadrature port	HP 46094A		150	900
6	3-Button mouse	HP 46095A		135	810
1	HP-UX prog. environ.	HP 98597A opt. 022	[note 3]	1,440	1,440
1	Common Lisp dev. environ.	HP 98678A opt. 022	[note 3]	4,000	4,000
1	HP-UX Fortran 77 compiler	HP 98598A opt. 022	[note 3]	800	800
1	HP-UX Pascal compiler	HP 98599A opt. 022	[note 3]	800	800
1	LaserJet Plus printer	HP 2686A with opt. 300		4,495	4,495
1	8-pen plotter	HP 7440A		1,295	1,295
2	404 Mbyte disk drives	HP 7935H	[note 4]	28,300	56,600
1	Dual 3.5" floppy drive	HP 9122D	[note 5]	1,390	1,390
2	GPIO interface board	HP 98622A	[note 6]	455	910
12	600' 1/4" tape carts. (5 per)	HP 88140LC		200	2,400
4	400 Mbyte disk packs			n/a	n/a
6	maintenance, Workstation		[note 7]	852	5,112
6	maintenance, "Falstaff" drive		[note 7]	n/a	n/a
6	maintenance, Cart-tape drive		[note 7]	132	792
1	maintenance, LaserJet printer		[note 7]	468	468
1	maintenance, 8-pen Plotter		[note 7]	48	48
2	maintenance, 404 mbyte drive		[note 7]	n/a	n/a
1	maintenance, Floppy drive		[note 7]	72	72
1	software updates, HP-UX	HP 98597A+S22	[note 7]	540	540
1	software updates, Lisp	HP 98678A+C00	[note 7]	264	264
1	software updates, Fortran	HP 98678A+C00	[note 7]	264	264
1	software updates, Pascal	HP 98678A+C00	[note 7]	264	264
				Total:	$390,036

[note 1] Workstation configuration similar to equipment in HP's AI Grants program

[note 2] Interfaces for digital audio equipment and real-time music synthesis

[note 3] Multi-user software and language systems

[note 4] Large capacity drives for digitized sound storage

[note 5] Needed for VMEbus and ADC interface driver releases

[note 6] Interfaces to custom peripheral devices

[note 7] One-year hardware maintenance contract (PMMC) or software materials subscription (SMS)

Student involvement at CCRMA is very interactive and represents a variety of interests and disciplines. Currently there are 29 graduate students and 10 advanced undergraduates working at the center. Areas of declared majors include Music, Electrical Engineering, Material Science and Engineering, Computer Science, Math, Psychology, Speech and Hearing Science, Aero-Astronautics, and Business.

Courses offered at the center include the following:

Music 220A - Fundamentals of Computer-Generated Sound

Introduction to computer-sound generation, basic mathematics of signal processing, and computer programming.

Music 220B - Composing Algorithms, Psychoacoustics, and Spatial Processing

Use of high-level programming language as a compositional aid in creating complex musical structures. Studies in the physical correlates to auditory perception, theories of hearing, and review of psychoacoustic literature. Simulation of a reverberant space and the control of the position of sound within the space.

Music 220C - Research

Research projects in composition, psychoacoustics, or signal processing.

Music 320A - The Discrete Fourier Transform

Fundamentals of spectrum analysis for discrete-time signals. Topics include sample signals, complex variables, geometric projection, orthogonality, the DFT, and Fourier theorems relating to time-shift, convolution, correlation, aliasing, signal power, symmetries, and bandlimited interpolation.

Music 320B - Applications of the Fast Fourier Transform

Spectrum analysis and digital filtering using the FFT. Topics include convolution, z transforms, transfer function analysis, frequency response, FFT windowing, and use of the FFT to implement non-recursive filters by means of the overlap-all filter-bank summation techniques.

Music 320C - Recursive Digital Filtering

Analysis, design, and implementation of recursive digital filters. Concepts include difference equations, impulse response, transfer function, frequency response, poles and zeros, stability, phase and group delay, partial fraction expansion, Schur algorithm, physical simulation, and structural/numerical issues.

Music 420A - Acoustical Signal Processing

Classical acoustics translated into a digital signal processing framework. Topics include mass-spring oscillation, the mass-spring chain, the wave equation for the ideal flexible string and acoustic tubes, traveling waves, wave impedance, scattering theory, signal energy and momentum, digital filter counterparts, allpass techniques, and efficent physical modeling using delay lines, scattering junctions, and low-order digital filters.

Music 420B - Nonlinear Modeling

Computational models for woodwinds and strings. Physically meaningful synthesis algorithms are built by coupling a "negative-resistance device" (such as provided by a woodwind reed or bow-string interaction) to a linear filter (which models a woodwind bore or vibrating string). The models are designed to capture only the "audible physics" of a musical instrument with a computationally simple algorithm.

Music 420C - Linear Modeling

Techniques for system identification and linear prediction. Computational methods are described for designing digital filters which automatically adjust free parameters to match physical measurements of linear resonating components of musical instruments. One well-known special case is linear predictive modeling of speech.

Recent dissertations have included:

Borish, Jeffrey. "Electronic Simulation of Auditorium Acoustics," PhD EE.

Gordon, John. "Percepton of Attack Transients in Musical Tones," PhD Music.

McAdams, Stephen. "Spectral Fusion, Spectral Parsing and the Formation of Auditory Images," PhD Speech and Hearing.

Schloss, Walter A. "On the Automatic Transcription of Percussive Music - From Acoustic Signal to High-Level Analysis," PhD Speech and Hearing.

Sheeline, Christopher. "An Investigation of the Effects of Direct and Reverberant Signal Interactions on Auditory Distance Perception," PhD Speech and Hearing.

Smith, Julius. "Techniques for Digital Filter Design and System Identification with Application to the Violin," PhD EE.

Strawn, John. "Modeling Musical Transitions," PhD Music.