EMAC: Engineering, Music and Art Collaboration

Dan Ellis, Electrical Engineering <dpwe@ee.columbia.edu>
Douglas Repetto, Computer Music Center <douglas@music.columbia.edu>
Alex Eleftheriadis, Electrical Engineering <eleft@ee.columbia.edu>
Brad Garton, Computer Music Center <garton@columbia.edu>

March 25, 2004

1 Introduction and Background

An ingredient essential to a “great university” is the breadth of scope from arts to sciences to professional and other specializations; the rationale for hosting these diverse disciplines within a single institution is that knowledge can be advanced and transmitted most effectively in a broad and open context that facilitates unexpected analogies and serendipitous encounters. This ideal, however, suffers many obstacles in practice: individual disciplines develop their own, mutually-incompatible languages and priorities, reflected in their institutions and resource allocations, seriously impeding the interdisciplinary opportunities that stand as one of the principle arguments in favor of the university concept.

Art and technology are sometimes discussed as diametrically opposed activities, but of course artists have been exploiting technology and pushing its limits since the first cave paintings. Digital technology is the current forum for this problematic relationship, with computers threatening some traditional art forms at the same time as opening up huge new opportunities for aesthetic expression.

The combination of a strong engineering school, innovative music and arts programs, and a location in the preeminent cultural center that is New York City, makes Columbia ideally placed to be a major venue for the mutual development and interaction between aesthetic and engineering practice. Our experience, however, as faculty working in closely related, complementary areas on either side of the art/technology divide, has been that traditional disciplinary structures, particularly with regards to funding, present major obstacles to the kinds of collaboration we would like to pursue. We see the Academic Quality Fund as an ideal vehicle to break this logjam.

Around the world, there has been an increasing realization of the importance and fertility of artistic-engineering collaboration, and that the major universities are the natural home for this kind of work. From the original visions of Stanford’s Center for Computer Research in Music and Acoustics (CCRMA), the NYU/Tisch Interactive Telecommunications Program, and MIT’s Media Lab, through to recent initiatives like the Arts, Media and Engineering program at Arizona, UCSB’s Interactive Multimedia Program, and the Center for Computational Creativity at City University in London, many schools have sought to construct environments in which the sometimes difficult dialog between artists and engineers can be optimally facilitated. One reason for the recent explosion of interest in these topics is the arrival of a new generation of students who grew up with the internet, and for whom technology is not an avocation in itself, but merely a tool that is expected to serve and be deployed in all fields of endeavor. Such students can be frustrated at the traditional disciplinary boundaries that require an exclusive commitment to either engineering or aesthetics, but not both.

The faculty behind this proposal have all been working for a long time in areas that include music technology. As such, each of us knows many examples of talented, curious students, with strengths both in engineering and creative areas, and indeed we may recall the points in our own careers where we had to make a choice along these lines to focus on a single major discipline. Despite the promise and opportunity of an institution like Columbia that includes both engineering and arts schools, we see these multi-talented students poorly served,
frustrated, and obliged to compromise on some of their intellectual goals. Despite significant personal motivation to work together across the art/technology divide, we have encountered strong normative forces keeping us within discipline boundaries, most significantly the reluctance of science and engineering agencies such as the NSF to support activities with a significant aesthetic component or goal. Thus, in spite of a wish to work together, collaboration has been limited to a few intrepid students taking courses outside their degree area on their own time. This seems like an injustice to the students, and a huge missed opportunity for Columbia.

This proposal seeks seed funding to initiate a collaborative project between faculty in Electrical Engineering (EE) and in the Computer Music Center (CMC) to support research in their common area of interest, the creation and analysis of music through digital technology. Collaborative teaching, group projects with students and faculty from different disciplines, and direct support of graduate students committed to multi-disciplinary research are the keys to making Columbia a primary destination for art and science savvy “renaissance” men and women of tomorrow looking to combine the best resources and knowledge in both art and technology.

1.1 The state of music-engineering research

Computer music is almost as old as electronic computers themselves, stretching back to the early experiments in singing synthesis and composition languages at Bell Labs in the 1960s (the inspiration for HAL’s swan song in the movie 2001: A Space Odyssey). The rise of electronic music in the 1970s and 80s has led to a significant commercial interest in music technology, including commercial research labs pursuing advanced projects. But the more scientific, exploratory and innovative aspects of music engineering have been left to universities, and have mostly been a marginal activity limited to a few small groups around the world.

There has, however, been a small boom recently in the field of musical signal analysis and information extraction that is one of our particular interests. The first International Symposium on Music Information Retrieval (ISMIR), held in Plymouth MA in 2000, has been followed by three more increasingly successful and vibrant events, bringing together computationally-oriented music theorists and musically-oriented engineers and information scientists. It is instructive, however, to look at the geographic distribution of contributors. The most recent ISMIR was held in Baltimore MD last October; of the 23 oral papers, 9 were from the US and 12 were from Europe, despite the American location which would encourage US participation (the remaining two papers were from Asia, and the 30 posters, presenting more preliminary work, were more equally divided between US, Europe and Asia). This supports our impression that the US academic environment presents particular barriers to this kind of work, something echoed in our survey of comparable groups in section 5. However, we see the comparative health of this activity in Europe as a good omen for the future: many of the European researchers are supported by recent projects funded by the EU, and it is likely that US funding agencies may soon also identify this area as an important source of intellectual and commercial growth.

1.2 Benefits

The proposed collaboration has many benefits for all the stake-holders:

- A major (yet artificial) intellectual barrier between engineering and the arts will be bridged in an organizationally robust way, providing both students and faculty with a supportive environment for creative achievement, both artistic and technical.

- Engineering students will have the chance to apply their skills in a different and exciting aesthetic domain, while remaining firmly grounded in a rigorous technical and scientific environment.

- Students working in arts and humanities areas will have a direct conduit to the most cutting-edge engineering techniques enabling the creation of unprecedented and high-impact artistic projects.

- All students will benefit from involvement in a focused and practical project, working with fixed time and financial resources, to achieve a concrete goal of which they can rightfully be proud, and which will
attract significant attention. For engineering students, involvement in such real-world projects with all the attendant pragmatic constraints, is actually a key component of the ABET accreditation requirements that will be uniquely fulfilled by this work.

- The departments involved, and the University as a whole, will profit from the favorable PR generated by media-friendly presentations of avant-garde art, helping to attract talented and original students and faculty to Columbia.

## 2 Project Description

The focus and unifying activity of this collaboration will be a series of specific projects whose outcomes are artistic/aesthetic creations including a strong and innovative technological component, emerging from a project class offered by the proposers. Building on similar classes previously offered by the CMC, this class will draw students from a wide range of backgrounds who will, through the course of the semester, design and implement a small number of technology-rich, aesthetically-oriented projects, working together in small teams. The end result will be an exhibition/performance of these pieces, either in an end-of-term event specific to the class, or perhaps contributed to a larger art event such as Artbot (described below).

The class will have a target enrollment of 10-20 students, including both graduate and undergraduate students, coming from Electrical Engineering or other engineering departments (e.g. Computer Science, Mechanical Engineering) as well as from Music and other humanities areas (such as the Art department and the Dance program at Barnard): it is the growing prevalence of students who are not bound by these traditional disciplinary boundaries and who would be enthusiastic to pursue activities complementary to their principal academic identification that makes this project so timely; for example, current computer music classes are often oversubscribed by hundreds of students. The core of the class will be a cadre of EE and CMC students directly supported through the project. Through their closer involvement with the themes and material, we can count on these students to contribute heavily to the class, but their formal status will be the same as all other students. We feel very strongly that, rather than labeling team participants as “creatives” or “engineers”, every student must participate on an equal footing and be free to explore and contribute their technical and aesthetic ideas to the fullest extent. Our goal is to produce well-rounded practitioners, and to put an end to the sometimes painful results that can occur when people attempt to cross the art/engineering boundary without a suitable guide for the far side.

While the purpose of the class will be clearly defined as the implementation of art projects (with an additional stipulation that the project be tangible, rather than a purely virtual or web-based outcome), the nature and form of these projects will be decided and developed entirely by the students. We wish to pursue a radical ‘classroom democracy’, where the class activities including the deployment of the project budget, are agreed among the students. Each student will be required to conceive and present at least one idea, but the scale of that idea could be one intricate detail, or a broad vision for an entire family of projects. Then, through discussion and negotiation, the class will be shepherded towards integrating and adapting these ideas into the final projects. Our past experience is that small teams of 2-4 students are most successful, but the class could equally choose to work as a single group on one mega-project.

The project definition process will operate with the specific motivation and constraint of the project budget of some $20k per class. We expect the specific availability of this money for equipment and materials will prove particularly stimulating to the students, at the same time as presenting a finite resource that they can compete for and obtain on the strength of their ideas. The ‘labor’ of individual students working on different teams will be another finite resource that individuals can strive to attract with superior proposals. Ultimately, the entire allocation of the budget and manpower will have to be agreed by consensus by the entire class, including the instructors.

Class-time activities will include lectures on specific tools and techniques of potential use to the projects, but again open to redefinition by the class participants. The instructors will provide a ‘menu’ of lectures or practical demonstrations they are able to provide, and the students have the chance to choose among them the most relevant
or attractive, or instead to spend the class time on other discussions, or even to request presentations on other topics, which the instructors would endeavor to provide. We will also bring in as guest lecturers relevant academic visitors (including those mentioned in section 5, and other people who stand as particularly fine examples of art and engineering integration - people like Jim Campbell, the MIT EE graduate with a dozen patents from his work in video circuit design, whose electronic art installations have appeared in prestigious venues including the 2002 Whitney Biennial Art Exhibition.

As a second outcome of the projects class, we will build up a portfolio of specific techniques and components, including software, electronic circuits, and other technology in the broadest sense, suitable abstracted to make them useful and applicable to other projects. These might include a signal processing routine to robustly recognize a clap signal, a circuit to interface a special-purpose temperature sensor to a computer, or a method for extracting and adapting electro-mechanical components from some consumer appliance for less conventional purposes. Each of these ‘idea components’ will be concise documented on a self-contained web page, and students will be given specific additional credit for completing these documents. The entire portfolio will constitute a growing resource library for later projects, but will also be freely and openly available via the web. Based on our previous experience, this kind of ‘publishing’ can have a surprisingly broad impact, and could be a significant vehicle for raising the profile and reputation of the collaboration; in an analogous (but smaller) effort, fragmentary example implementations of particular audio processing algorithms, originally developed for classroom demonstrations were gathered on a web site mainly aimed at students from the class. By the graces of web search engines, this collection has, however, been repeatedly discovered by students and researchers all over the world, resulting in a steady stream of grateful and complimentary email messages. http://www.ee.columbia.edu/~dpwe/resources/matlab/ The CMC is already well known as a source of innovative software and hardware tools and techniques for computer music and interactive art. Much of the work done at the CMC is made freely available online, and we encourage our students to embrace knowledge sharing, public peer review, and community building as a core part of their practice. http://music.columbia.edu/cmc/software/index.html

An important element of the class will be the public presentation of the works created during the term. Producing a high profile event will benefit the students and the collaboration in a number of ways. The pressure of producing such an event will encourage students to take seriously their commitment to the class and the projects they initiate. It will give them real world experience in planning and meeting deadlines, producing public events, generating publicity for their work, and presenting their work to outsiders. At the same time, public, high profile events highlighting innovative work at Columbia are essential to bootstrapping this kind of activity. If we are to attract students interested in doing such innovative work, as well as corporations and foundations interested in funding it, we must first make it clear that Columbia is a place where such work is valued, encouraged, and actively supported. The public presentation of such work is an essential step toward that goal.

The ITP program at NYU is an interesting model for this sort of public presentation. Each term the instructors curate a large group show that includes the work of many of the over 200 students enrolled in the program. NYU then does extensive PR for the show, which attracts hundreds of students and professionals from the art, engineering, and industrial worlds. The result is that NYU’s ITP program is known as one of the nation’s top destinations for students interested in combining art and technology. An interesting aspect of the NYU ITP show is that the quality of the work is often uneven, and many attendees tend to be quite critical of the event. So it is not the quality of the work that has engendered the ITP program’s reputation; rather, it’s the simple fact that they consistently present the work and make the point that NYU actively supports such endeavors. Although our initial efforts would necessarily be much more modest than those of the ITP program, it’s important to note that simply presenting work in high profile events is an essential first step.

The CMC is currently engaged in the production of a number of such events, including concerts in venues around the city, CD releases, and the annual ArtBots: The Robot Talent Show, which has received copious national and international press for the last three years.
2.1 Space

Space is a continual challenge for many activities at Columbia, and ambitious art projects with innovative virtual-physical components can be particularly difficult to host. At present, the CMC has space in the old Prentis building on 125th St., which includes a number of rooms that can be largely dedicated to the use of a single project over semester-length periods. A fixed location to work on the project is a real necessity for the kind of integrated, artifact-based work we wish to facilitate, and also promotes the collaboration and involvement of students. A unique and exciting construction, built from the components purchased with the budget, and representing the cumulative work on the project, will act as the 'magnet' bringing students into the project space to collaborate and create. In particular, the EE students supported through this proposal will, like other engineering graduate students, be found office/lab space, most likely in Mudd. These students will need a good reason to travel up to Prentis where they can mingle with the other students; the project space and the newly-bought equipment located there will provide this pull.

(At present, the future of Prentis is uncertain, and the CMC may have to move within the next few years to permit its redevelopment. However, providing space for projects of this kind will be a priority for whatever new space the CMC identifies.)

On the other hand, certain components that might be impractical to manufacture in Prentis could be developed at the new Student Projects Lab recently opened in Mudd by the EE department. This lab is always available for undergraduate and graduate students to work on individual electronics projects, and is fully decked-out with tools and test equipment. With our sponsorship, these facilities could be available to people other than engineering students with an interest in developing their own custom circuitry. An attraction of locating some of the project work in this space is that it will expose a very different population to the activity, drawing in circuits-oriented students and even faculty to a growing collaboration.

3 Context and Integration

This collaboration is a logical extension of existing research and teaching by the proposers, and will complement and enhance a range of current activities. In EE, Eleftheriadis and Ellis teach the core introductory signal processing at undergraduate and masters level. Signal processing is the core discipline connecting engineering practice with musical sound, and musical illustrations are frequently used in both classes, serving to entice students into further pursuit of this area. Eleftheriadis also teaches ELEN E4896 Music Signal Processing which directly concerns the technological aspects of contemporary music creation, and would be highly complementary to the proposed new project course http://www.ee.columbia.edu/~eleft/e4896. Ellis teaches ELEN E6820 Speech and Audio Processing and Recognition, a broad course covering analysis and processing of sounds of all kinds http://www.ee.columbia.edu/~dpwe/e6820/. This course has spawned a mini-course on pattern recognition for musical signals that he has delivered as a guest lecturer at Johns Hopkins University, as well as at Universitat Pompeu Fabra in Barcelona http://www.ee.columbia.edu/~dpwe/muscontent/.

The Speech and Audio class has been the origin of several of the relevant existing EE research projects in this area. We have published papers on analysis and synthesis of sound ‘textures’, identifying segments of signing within music recordings for the purposes of artist identification, automatic alignment and segmentation of music into symbolic descriptions, and transcription of music audio into chord and note representations. (Because of the difficulties in funding music research through conventional engineering channels, much of this work has been with ‘volunteer’ labor, underlining the huge enthusiasm for this kind of work). http://labrosa.ee.columbia.edu/projects/music/

The CMC has offered a number of experimental courses in collaboration with other departments and schools at Columbia in recent years. The class at the center of this proposal would be modeled on those classes and would draw from the considerable experience accumulated in running such classes. It can be difficult to make such collaborative classes work, particularly when the students come into the class with very diverse backgrounds and skill sets. That said, the last few classes we’ve given have been quite successful, and we’re confident that we
have a good understanding of how to put such a class together. The classes include:

- **Interactivity Outside the Box** (Spring 2000): Students from the School of the Arts collaborated with students from the CMC to make large scale projects. Documentation: [http://music.columbia.edu/cmc/courses/r6505/](http://music.columbia.edu/cmc/courses/r6505/)

- **Sensors and Microcontrollers for Music Types** (Fall 2000): a mini class meant to get musicians up to speed on building simple electronic devices. This class was very well received and there is constant demand for more classes like this. Documentation: [http://music.columbia.edu/cmc/modules/HCI/](http://music.columbia.edu/cmc/modules/HCI/)

- **Sound/Image** (Spring 2003, Fall 2003, Spring 2004): This has become a regular interdisciplinary class that we teach each term in collaboration with the SoA. Each term it is different, depending on the needs and interests of the students and faculty. In Fall 2003 it focused on the creation of real time interactive audio and visual systems ([http://music.columbia.edu/cmc/courses/R6006](http://music.columbia.edu/cmc/courses/R6006)) and this spring we are developing site-specific audio-visual installation works inspired by the Thomas Alva Edison National Historic Site in West Orange, New Jersey.

A number of significant works, as well as fruitful ongoing collaborations, have resulted from these experimental classes. Of particular importance has been the financial support we’ve been able to offer to the students. Student ambition very quickly out-paces their financial resources. The modest materials budgets we’ve allocated for these experimental classes have allowed students to attempt works on a scale that would otherwise be inaccessible to them. Below we will highlight a few successful projects from the last few years.

- **Tristan Perich: CubeScreen.** Tristan created a three dimensional video screen using thousands of feet of fiber optic cables, a laptop, a video projector, and a novel software 3D-2D mapping technique. He arranged the tips of one end of the fiber optic cables in a large suspended three dimensional cube. The other ends are arranged in a two dimensional grid. Tristan’s custom software takes a three dimensional image and encodes it in two dimensions for projection onto the two dimensional grid. Those images travel down the cables and are emitted in the three three dimensional cube.

- **The Tuesday Group: OverTime.** This collaborative group, consisting of three dancers, two visual artists, and three musicians, has, in a variety of configurations, created a series elaborate performance pieces. The works have involved custom movement tracking technology, giant inflatable pneumatic devices, acoustic instruments, video projections, and custom audio processing algorithms. Members of the group have continued working together to expand and refine the techniques they developed during their original collaboration in the Movement-Sound Interaction class.

- **Michael Prerau: Intelligent Dance Agent/Dance Tracker Library.** Michael has taken a number of our classes in which he has collaborated extensively with dancers. His dual interests in video analysis and dance have led him to develop a number of software and hardware tools to facilitate the analysis and synthesis of dancer movements. In one project, “Pas de Dieu”, he built a system that would track the movement of a real dancer on a stage, analyze that movement, and then simulate the movement of a virtual dancer by moving a custom robotic spotlight around the stage. The result was an improvised duet between the real dancer and a virtual partner.

The problems we have identified and are trying to address have also been identified by other parts of the institution. For instance, the School of the Arts recently hired Mark Tribe as their new Director of Digital Media, with an explicit mandate to facilitate and support technologically ambitious work in the School of the Arts. Columbia is known as a source of innovation in many fields, but its reputation in the arts, while strong in many traditional areas, is not one of technological sophistication. Over the past several years the CMC has been working closely with the School of the Arts and the Digital Media Center to support interdisciplinary work via a series of co-sponsored courses. Additionally, this year the DMC and the CMC have co-sponsored the Art
& Technology Lectures Series, in an effort to bring internationally known artists, theorists, and technologists to Columbia to help highlight our commitment to and engagement with these issues.

4 Team

The faculty directly involved in this proposal are:

**Dan Ellis**, Assistant Professor, Electrical Engineering. Dan Ellis, who will be the faculty leader of this collaboration, joined Columbia in 2000 and runs the Laboratory for Recognition and Organization of Speech and Audio (LabROSA). Before that, he was working on speech recognition in Berkeley, and before that he was a graduate student in the Machine Listening Group (now the Music, Mind and Machine group) at the MIT Media Lab. Music was the draw that originally interested him in signal processing and engineering, and he has been experimenting with sound and computers since high school. One of the missions of LabROSA has been the transfer of ideas and techniques from speech recognition to other kinds of audio, and of the nine US-originating papers presented at the recent Music Information Retrieval conference ISMIR-04 (mentioned in the introduction), three were from LabROSA.

**Douglas Repetto**, Adjunct Assistant Professor, Music. Douglas Repetto is an artist and teacher. His work, including installations, performances, recordings, software, and lectures, has been presented internationally. He runs a number of arts/community-oriented groups in New York City and on the web, including dorkbot: people doing strange things with electricity, ArtBots: The Robot Talent Show, organism: making art with living systems, and the music-dsp mailing list and website.

**Alexandros Eleftheriadis**, Associate Professor, Electrical Engineering. Alexandros Eleftheriadis is the director of the Multimedia Signal Processing Laboratory and co-principal investigator in the ADVENT Project, an industrial affiliates program that investigates all aspects of digital video processing, coding, and communication. He has been working in the area of multimedia signal processing, with emphasis on digital video compression and communication, as well as techniques and software for media representation. He has been involved in the development of a number of international standards, including MPEG-4 where he served as the Editor of the Systems specification. Motivated by considerable involvement in music (study of music theory and performance on several instruments), he recently expanded his research and teaching activities into music engineering as well, with emphasis on music recording/production and composition software tools.

**Brad Garton**, Professor, Music. Brad Garton is currently on the Music Faculty of Columbia University, where he serves as Director of the Computer Music Center (formerly the Columbia-Princeton Electronic Music Center). He originally studied engineering/biology at Purdue University, ultimately receiving a BS in Pharmacology. His current work includes focused research on the modeling and enhancement of acoustic spaces as well as the modeling of human musical performance on various virtual “instruments”. He is also the primary developer (with Dave Topper) of RTcmix, a real-time music synthesis/signal-processing language.

We have also discussed this project with many of our colleagues, and have had explicit expressions of interest from other EE faculty including Yannis Tsividis (analog circuits), Computer Science faculty including David Waltz and Tony Jebara (Machine Learning), Kathy McKeown (Natural Language Processing), and Elizabeth Sklar (Robotics and Embodied Agents), as well as Psychology professor Robert Remez (human sound perception and organization).

5 Sustainability

We are seeking three years of AQF funding for this collaboration with the goal of establishing a self-sustaining activity within that time-frame. Funding for this kind of mixture of artistic and scientific work is certainly a challenge, but the key factor is to have the reputation to give funders confidence that their money will be well spent. We will use this initial period of Columbia-internal funding to establish such a reputation.

Our vision is that, three years from now, we will be approaching the culmination of our third offering of the Engineering Music Art project class, riding on the success and attention attracted by the exciting and striking
projects completed in the previous two years. By this time, the press coverage of our project presentation events, our presentations at both art and engineering venues, and the web-based resources we have made available will have resulted in many top-caliber students actively seeking out Columbia for their studies for the express purpose of participating in this activity. The credibility built through a succession of well-executed projects that combine unique, unprecedented technical components into vibrant and noteworthy artistic creations will attract one segment of the funding community, while our series of top-quality, rigorous technical publications describing the innovations included in each project, will satisfy another. To further cement our identity as a key center for technical academic work in this field, we will plan to host a conference in this area in late 2006, possibly that year’s ISMIR.

For greater specificity in identifying potential future funding sources, we have conducted a survey of our colleagues working in similar areas on the boundary of music and engineering:

- Stanford Center for Computer Research in Music and Acoustics (Julius Smith). CCRMA was founded in 1975 largely on the strength of John Chowning’s patent on the FM music synthesis technique, which, through Yamaha’s licensing, powered the synth-pop boom of the mid 1980s; their research focus has remained technologies for music creation. CCRMA has an endowment based on the FM patent, some other licensing income, and an industrial affiliates program. http://www-ccrma.stanford.edu/

- MIT Media Lab Music Mind & Machine Group (Barry Vercoe). As part of the Media Lab since its creation in 1985, this group with its mixed emphasis on music creation, music perception, and other related ideas, has been funded by the Lab’s unique and highly successful industrial sponsorship program which mixes IP, corporate PR, and the ability to act as a neutral meeting ground for sponsors. (Proposer Ellis is a graduate of this group.) http://sound.media.mit.edu/

- UC Berkeley Center for New Music and Audio Technologies (David Wessell). Founded in 1987, this group is strongly focused on music performance but at the same time has developed some important new technologies, leading to some direct industrial sponsorship. Foundations, private donors, and a small industrial affiliates program round out the funding picture. http://www.cnmat.berkeley.edu/

- UC San Diego Center for Research in Computing and the Arts (Miller Puckette). Originally founded as the Center for Music Experimentation in 1972, CRCA hosts artist-engineers with an emphasis on arts events. In recent years, foundation funding has given way to a mix of local industry and arts organization, as well as a substantial involvement in the California State CalIT2 initiative to maintain leadership in internet technologies. http://www-crca.ucsd.edu/

- Princeton SoundLab (Perry Cook). A graduate of CCRMA, Cook has been at Princeton since 1996, running a lab that spills beyond music synthesis into other audio and Human-Computer Interface technologies. By maintaining a high press profile, he has been successful at collecting gifts and grants from local industry and alumni, as well as some NSF and NJ state money. http://soundlab.cs.princeton.edu/

We will pursue funding from a similar range of sources. Specifically, the NSF has proven an unreliable friend to music, but we remain optimistic that they can be persuaded. A search of their current projects reveals a handful of music-related topics from several different programs; discussions with the PIs involved has uncovered no magic formula. We will refine an argument based on (a) the scientific merit of music-related problems as a way to study human information processing and human-computer interaction; (b) the broader impact to a large section of society of developing and refining tools to facilitate unimpeded self-expression; and (c) the economic importance to the United States of maintaining a lead in these areas – particularly in light of the vigorous competition represented by EU funding of music technology research. Ellis and Eleftheriadis receive significant current support from the NSF (on non-music projects), and Ellis has received “competitive” ratings on his most recent (unfunded) music-related proposals to that agency.

The NSF also has a mandate to improve education and training; the very broad range of skills and activities involved in this collaboration make it an excellent vehicle for this goal. In addition to research-oriented projects,
we will pursue education-related programs such as Integrative Graduate Education and Research Traineeship which particularly favors the kind of deep multidisciplinary interaction we hope to attract around this collaboration (UCSB’s Interactive Multimedia Program is supported by IGERT). Involving undergraduates in research is another activity favored by the NSF, and a natural part of our open, eclectic projects.

**Industrial Sponsorship** has become increasingly difficult in recent years, although we can hope this trend will have turned around by 2007. Despite this, we have actually been moderately successful in that the only funding specifically for music work in LabROSA has come from a few small projects with Google and NEC Research Labs. We will continue to cultivate contacts at local research labs in the hope of expanding this; current links with IBM (Yorktown Heights), HP (Cambridge), MERL (Cambridge) and Philips (Briarcliff Manor) will be further reinforced with continued academic collaborations and internships. At least HP and Philips are explicitly interested in music technology.

**Private Foundations** and **Corporate Sponsorship** have been the mainstay of CMC funding. Recent large scale projects have been supported by JPMorgan Chase (The Kids Digital Movement and Sound Project), Lincoln Center (Masterpieces of Electronic Music), and The Goodman Foundation (The Digital Sound Environments Project). The CMC’s reputation as an historical leader and present day innovator in the computer music field, as well as the well publicized success of many recent events, has made it an attractive grantee. Within the collaboration, we will borrow and build upon this reputation.

### 6 Budget

We are seeking support for two graduate students in Electrical Engineering, who will be supervised by the two EE faculty proposers, and partial support for two CMC students, who already receive academic year funding through the Music Department. Salary support for the EE faculty to cover their time spent developing this program is also requested. Tuition for the EE students, which cannot be provided through the AQF, will be found elsewhere; for the first year, we have industrial gift money available.

The special and customized equipment requirements of the major art/technology projects to be staged through this effort require in the range of $10-$15,000 per project; we have budgeted a total of $25,000 for two projects per year, including funding for the project presentation event. As an example of how this money will be spent, consider the CubeScreen project described above: To create his three-dimensional luminous display, Tristan required a $2,000 video projector, a $1,600 laptop, $700 of fiber optic cable, and $200 for the remaining hardware components ($4500 total). Such projects can quickly become expensive, but generous support can release great ideas.

We are requesting support for three years to provide stability and security for the graduate students involved, and to give us adequate time to develop a compelling package to offer to longer-term funding sources.