PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION
Cover Page

FOR CONSIDERATION BY NSF ORGANIZATIONAL UNIT (Indicate the most specific unit known, i.e. program, division, etc.)	IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? Yes ___ No XX ; IF YES, LIST ACRONYM(S):
Mathematical and Computer Sciences	

PROGRAM ANNOUNCEMENT/SOLICITATION NO.:	CLOSING DATE (IF ANY):

NAME OF SUBMITTING ORGANIZATION TO WHICH AWARD SHOULD BE MADE (INCLUDE BRANCH, CAMPUS, OTHER COMPONENTS)

Stanford University

ADDRESS OF ORGANIZATION (INCLUDE ZIP CODE)

C/O Sponsored Projects Office, Encina Hall, Stanford, CA 94305, Phone: (415) 497-2883

TITLE OF PROPOSED PROJECT

An Intelligent System for the Knowledge-Driven Analysis of Acoustic Signals

REQUESTED AMOUNT	PROPOSED DURATION	DESIRED STARTING DATE
$354,954	2 years	June 1, 1983

PI/PD NAME AND SOCIAL SECURITY NO (SSN)*	PI/PD PHONE NO
Music Department	(415) 497-4971

PI/PD DEPARTMENT	PI/PD ORGANIZATION
Music Department	CCRMA

ADDITIONAL PI/PD AND SSN*	ADDITIONAL PI/PD AND SSN*

ADDITIONAL PI/PD AND SSN*	ADDITIONAL PI/PD AND SSN*

FOR RENEWAL OR CONTINUING AWARD REQUEST, LIST PREVIOUS AWARD NO.: MCS 80-12476	SUBMITTING ORGANIZATION IS ___ IS NOT ___ A SMALL BUSINESS CONCERN (see CFR Title 13, Part 121 for definitions).

*Submission of social security numbers is voluntary and will not affect the organization's eligibility for an award. However, they are an integral part of the NSF information system and assist in processing the proposal. SSN solicited under NSF Act of 1950, as amended.

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW:

- ☐ Animal Welfare
- ☐ Human Subjects
- ☐ National Environmental Policy Act
- ☐ Endangered Species
- ☐ Marine Mammal Protection
- ☐ Research Involving Recombinant DNA Molecules
- ☐ Historical Sites
- ☐ Pollution Control
- ☐ Proprietary and Privileged Information

PRINCIPAL INVESTIGATOR/ PROJECT DIRECTOR	AUTHORIZED ORGANIZATIONAL REP.	OTHER ENDORSEMENT (optional)
NAME: John M. Chowning	NAME:	NAME:
SIGNATURE:	SIGNATURE:	SIGNATURE:
TITLE: Professor of Music	TITLE:	TITLE:
DATE: February 18, 1983	DATE:	DATE:

NOTICE OF RESEARCH PROJECT

SCIENCE INFORMATION EXCHANGE

SMITHSONIAN INSTITUTION
NATIONAL SCIENCE FOUNDATION

PROJECT SUMMARY

SIE PROJECT NO.
NSF AWARD NO.

FOR NSF USE ONLY			
DIRECTORATE/DIVISION	PROGRAM OR SECTION	PROPOSAL NO.	F.Y.

NAME OF INSTITUTION (INCLUDE BRANCH/CAMPUS AND SCHOOL OR DIVISION)

Sponsored Projects Office,
Encina Hall
Stanford, CA 94305

ADDRESS (INCLUDE DEPARTMENT)

Center For Computer Research in Music and Acoustics (CCRMA)/MUSIC DEPARTMENT
Stanford University
Stanford, California 94305

PRINCIPAL INVESTIGATOR(S)

John M. Chowning, Professor of Music

TITLE OF PROJECT

An Intelligent System for the Knowledge-Driven Analysis of Acoustic Signals

TECHNICAL ABSTRACT (LIMIT TO 22 PICA OR 18 ELITE TYPEWRITTEN LINES)

The central concern of the research proposed is the integration of signal processing and context analysis into a goal-directed analysis based system for the understanding of complex structured acoustic signals. There are two aspects to this approach to the problem. First, a control strategy will be designed to employ all levels of analysis, including the signal processing, in a common control mechanism. This is in contrast to previous efforts that have viewed signal processing as a frontend pipeline process. The control strategy will be developed using heuristics and resource allocation algorithms to invoke relevant knowledge sources at appropriate processing stages. The second aspect is the guiding of the signal processing by the higher levels of analysis so that the signal processing tools can be invoked to reprocess certain portions of the incoming signals, and the higher levels can feed back parameters to direct the signal processing to a more accurate analysis of the signal.

1. Proposal Folder
2. Program Suspense
3. Division of Grants & Contracts
4. Science Information Exchange
5. Principal Investigator
6. Off. of Govt. & Pub. Progs.

NATIONAL SCIENCE FOUNDATION

PROPOSAL EVALUATION FORM

NSF Form 1B (9-81)
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PROPOSAL NO.	INSTITUTION	PLEASE RETURN BY
MCS-8214350	STANFORD UNIV	

PRINCIPAL INVESTIGATOR	NSF PROGRAM
CHOWNING JOHN M	INTELLIGENT SYSTEMS PROG

TITLE

AN INTELLIGENT SYSTEM FOR THE KNOWLEDGE-DRIVEN ANALYSIS OF ACOUSTIC SIGNALS

COMMENTS (QUALITY OF THE PROPOSED RESEARCH, RECENT RESEARCH ACHIEVEMENTS OF THE PRINCIPAL INVESTIGATOR(S), ETC.) CONTINUE ON ADDITIONAL SHEET(S) AS NECESSARY.

It has been clear for some time that computer recognition has reached the limits of what can be done at the signal processing level, yet few people know enough about AI and signal processing to try to link them. This group clearly has the requisite skills and knowledge, access to enough computing power, and promising early results. The proposed research is highly exploratory, of excellent quality, and is of extreme importance to all recognition work. They are closing on a solution to the "cocktail party" problem.

Chowning's past research efforts have been a few carefully chosen efforts which have made fundamental contributions to knowledge (FM, spatial processing). He does not squander effort.

OVERALL RATING: [XX] EXCELLENT [ ] VERY GOOD [ ] GOOD [ ] FAIR [ ] POOR

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TITLE

AN INTELLIGENT SYSTEM FOR THE KNOWLEDGE-DRIVEN ANALYSIS OF ACOUSTIC SIGNALS

COMMENTS (CONTINUE ON ADDITIONAL SHEET(S) AS NECESSARY)

QUALITY OF THE PROPOSED RESEARCH (INCLUDING BUDGET AND INSTITUTIONAL CAPABILITY):

I cannot recommend this proposal more highly.

Both in terms of scientific quality and the researchers' capabilities, this is an outstanding project which deserves the full support of the Foundation.

How many projects combine and bear fruit in fields as diverse as signal processing, artificial intelligence, and acoustics, while having profound implications in the arts? The benefits of such research to the music recording industry are clear. Another thing that seems special about this project is that it is uniquely American: the highest technology applied in the musical domain. We can be proud to be leaders in applying technology creatively. The budget seems reasonable, especially since equipment is not needed.

RECENT RESEARCH ACHIEVEMENTS OF THE PRINCIPAL INVESTIGATOR(S):

The team assembled for this project is very strong. Drs. Chowning, Mont-Reynaud, and Rush are well-known for the high scientific quality of their research. The Principal Investigator, Dr. Chowning, has helped to set high standards in computer music research with his landmark papers on the movement of sounds in space (1971), frequency modulation synthesis (1973), and synthesis of the singing voice (1980), while directing the Center for Computer Research in Music and Acoustics at Stanford.

OVERALL RATING: [X] EXCELLENT [ ] VERY GOOD [ ] GOOD [ ] FAIR [ ] POOR

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COMMENTS (CONTINUE ON ADDITIONAL SHEET(S) AS NECESSARY)
QUALITY OF THE PROPOSED RESEARCH (INCLUDING BUDGET AND INSTITUTIONAL CAPABILITY):

This is an ambitious program in an area which has been comparatively little researched and which should provide useful data for a number of related fields with needs for acoustic pattern recognition. Of particular interest is the proposed feedback between the high-level artificial intelligence part and the low level signal processing. The budget seems to be in line with the needs of the project and CCRMA already has an impressive record in researching computer applications in acoustics. The potential problem areas seem to have been well identified in the proposal and there is every reason to believe that the researchers will be successful in realizing a large part of their aims.

RECENT RESEARCH ACHIEVEMENTS OF THE PRINCIPAL INVESTIGATOR(S):

The background of the proposed team would seem to well equip them for the research involved.

OVERALL RATING: ☐ EXCELLENT ☑ VERY GOOD ☐ GOOD ☐ FAIR ☐ POOR

Verbatim but anonymous copies of reviews will be sent only to the principal investigator/project director. Subject to this NSF policy and applicable laws, including the Freedom of Information Act, 5 USC 552 and formal requests from Chairpersons of Congressional committees having responsibility for NSF, reviewers' comments will be given maximum protection from disclosure.

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COMMENTS (CONTINUE ON ADDITIONAL SHEET(S) AS NECESSARY)
QUALITY OF THE PROPOSED RESEARCH (INCLUDING BUDGET AND INSTITUTIONAL CAPABILITY):

It seems to me this is an excellent proposal for a small amount of funding--much less than is being requested. In the past, I would have been very skeptical of the value of such an "AI" approach to the analysis or "automatic recognition" of acoustic signals. In essence, what is being proposed is an automatic recognition project for music. It will face problems similar to automatic recognition of speech.

However, the vastly increased computational power currently available, and the development of the expert systems (knowledge-driven analysis) approach to such problems makes this research much more hopeful. However, it is still very exploratory, and it would seem to me that initial support of one or two people for a couple of years would be more appropriate than the amount requested.

I have the highest regard for Chowning, Rush, and Smith. Chowning has a long history of achieving the best things in the world in computer music. Smith has just finished a first-rate PhD thesis on the analysis of violin tones. Rush is an excellent composer with a lot of experience with computers. I don't know Green, but a reliable associate says he is competent. Hence, I think the personnel are O.K.

RECENT RESEARCH ACHIEVEMENTS OF THE PRINCIPAL INVESTIGATOR(S):

This is a duplication of comments on Proposal No. MCS-8214357.

OVERALL RATING: ☒ EXCELLENT ☐ VERY GOOD ☐ GOOD ☐ FAIR ☐ POOR

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PRINCIPAL INVESTIGATOR	NSF PROGRAM
CHOWNING JOHN M	INTELLIGENT SYSTEMS PROG

TITLE

AN INTELLIGENT SYSTEM FOR THE KNOWLEDGE-DRIVEN ANALYSIS OF ACOUSTIC SIGNALS

COMMENTS (CONTINUE ON ADDITIONAL SHEET(S) AS NECESSARY)

QUALITY OF THE PROPOSED RESEARCH (INCLUDING BUDGET AND INSTITUTIONAL CAPABILITY):

This collaborative research is aimed at developing methods for the analysis of complex acoustic signals in general, with particular application to music. Thus, while computer "understanding" of music, i.e., derivation of an automatic transcription from digitized musical sounds, is the immediate goal of the research, the real objective is less concerned with music per se than with working out a general-purpose methodology applicable to speech or speaker recognition and a variety of other complex input signals. The focus of the methodological research will be on incorporating the signal processing -- usually treated as a front-end operation -- into the overall control strategy. Signal processing can then be guided by higher levels of analysis, i.e., invoked as needed, supplied with parameters, or directed to reprocess selected parts of the input.

Both the general problem of methodology add the specific problem of computer transcription of music are significant ones. The two (nearly identical) proposals put these problems clearly and insightfully against a background of research on music that has already been done at the Stanford laboratory. The plans for continuing this research and for using it to try out various components of the proposed methodology are reasonable and likely to lead to useful algorithms for music analysis and to further insights into how "expert systems" must be designed. The investigators appear to be thoroughly competent and the facilities at both organizations are excellent.

RECENT RESEARCH ACHIEVEMENTS OF THE PRINCIPAL INVESTIGATOR(S):

Some comments and caveats are, however, in order:

(1) The applicants point (repeatedly) to the novelty of their concept of goal-directed signal processing. One can agree that the usual procedure is to treat signal processing as a once-and-for-all front-end operation, but the idea -- and even the practice -- of reanalysis under guidance of control strategies was not unknown in speech understanding research as far back as the ARPA program. Nevertheless, absolute originality aside, the idea is a good one and certainly deserves the attention here proposed.

(2) Although the research problems are well described, the proposal says rather little about specific research plans, even in the section labeled "Proposed Research".

OVERALL RATING: ☐ EXCELLENT ☒ VERY GOOD ☐ GOOD ☐ FAIR ☐ POOR

"An Intelligent System for the Knowledge-Driven Analysis of Acoustic Signals"

NSF Program: Intelligent Systems Program

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(3) The plans, stated and implied, are largely open-ended. While I believe this to be a fair characterization, open-endedness is not necessarily a fault, given a good track record and a problem as complex as the one here proposed.

(4) The choice of music as a test-bed for developing analysis strategies and algorithms is entirely reasonable, but a focus on live performances and expressive renditions may be questioned on two counts: the sheer difficulty of the task may then defeat even "good" methods; also, attending to the complexities introduced by live performance may lead to special-case solutions and divert attention from methods that would be applicable to a broader range of complex signals. However, the applicants seem not to have fallen into this trap in the past and they do consider even the use of synthetic music -- in which complexity can be tightly controlled -- for some of their studies.

While the paucity of specific information about plans for the research raises no serious problems for this reviewer, the same cannot be said about the plans for cooperation between the two organizations. The one page devoted to Joint University/Industry Research says that the cooperative effort takes many forms, and that there is strong technical support between the two organizations -- but that is about all it says. It leaves unanswered such questions as "What does the problem require that the Stanford group cannot provide, given that the Stanford group has been doing the bulk of the research on music analysis?", or "What arrangements are there for effective collaboration and coordination of effort?" "Are there specific facilities or people essential to the research and available only through a collaborative arrangement?"

The above paragraph may seem to reflect a somewhat negative attitude toward collaborative research. In fact, I am strongly in favor of such arrangements provided (a) there is active cooperation that enhances the research and (b) the costs are reasonable as compared with other possible arrangements. In the present case, there is insufficient information to reassure me about actual cooperation, and the budgets to <u>not</u> reassure me about cost effectiveness.

It may well be that these considerations should not enter into my review of this proposal, inasmuch as cost effectiveness and university/industry collaborative arrangements are policy issues for the Foundation to resolve. It is true, though, that the less-than-excellent ratings I have given these proposals reflects these factors rather than my valuation of the research <u>per se</u>.

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COMMENTS (CONTINUE ON ADDITIONAL SHEET(S) AS NECESSARY)
QUALITY OF THE PROPOSED RESEARCH (INCLUDING BUDGET AND INSTITUTIONAL CAPABILITY):

This proposal in its broadest sense, is directed at developing concepts and tools for combining the disciplines of signal processing and expert systems. In the proposal they have clearly identified the principal weakness of such interaction in the past, specifically the decoupling. Thus, I feel strongly that the emphasis on goal-directed signal processing is appropriate, timely and an important research direction. In my view, one of the difficulties in the past with combining signal processing and artificial intelligence concepts has been that problems of considerable magnitude have typically been chosen which very quickly led to partitioning of the problem along cultural lines, namely the signal processing and AI aspects. In the context of the current proposal, I feel that the researchers should be encouraged to keep the goals of the processing as modest as possible to enhance the opportunity for exploring the concepts of goal-directed signal processing. I personally believe that the objectives outlined in the proposal of generating a map of music including details of phrasing

RECENT RESEARCH ACHIEVEMENTS OF THE PRINCIPAL INVESTIGATOR(S):

OVERALL RATING: ☐ EXCELLENT ☒ VERY GOOD ☐ GOOD ☐ FAIR ☐ POOR

nuances is overly ambitious, and not likely to be successful in the short run. Out of an attempt to do this, particularly if more modest goals are picked, is likely to develop some important control strategies and architectural issues for having effective interaction between the signal and symbol processing parts of the system.

Overall, I feel that the direction indicated in this proposal is important and that the investigators are among the best qualified to pursue it. Consequently, I would strongly encourage support for the proposed research.