AMUS: THE COMPUTER IN MUSIC INSTRUCTION

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Introduction

On first thought, the complexity and sophistication of the computer would appear to have little to offer to our musical art. However we, as musicians, know the complex sophistication which music encompasses; computer technology has proved to be of great assistance in both the creation and the pedagogy of music, and has expanded the horizons of a variety of musical endeavors.

The development of interactive text-processing computer systems has made computer-assisted instruction (CAI) practical, even for teachers and students who have no previous computer experience. At North Texas State University (NTSU) and elsewhere, microcomputer technology has vastly expanded the range of situations and people served by CAI, enabling complex problems, such as sound generation, to be solved on small systems. Microprocessors can be used by themselves or can be interfaced to large timesharing systems. This merger at NTSU of a timesharing text-processing computer system with microprocessing sound synthesizers is an instance of distributed computer processing

CAI has proved particularly effective in meeting the special needs of ear-training instruction, such as:

1. need for a dependable sound source;
2. need for immediate repetition of sound, controlled by the student;
3. need for easy access to drill and practice;
4. need for immediate student evaluation and reinforcement.

Background and History

Some of the earliest uses of computers in music were in computer-assisted analysis of compositional styles, since this could be done within the constraints of the technology of the day. CAI developed with the advent of timesharing, which allows a number of people to interact with the computer simultaneously and improved the economics of computer usage. Among early developments in ear-training CAI were those at Stanford University and the University of Delaware, in 1972 (1,2).

NTSU's contribution to the use of computers in music began with the work of D. W. Scott, Chairman of the Computer Sciences Department. His microprocessor-based synthesizer provides real-time simultaneous generation of up to eight separate musical voices. The Automatic Music System (AMUS) employes a simple and flexible encoding notation for multi-voice compositions. Dr. Scott designed and developed the AMUS scoring notation, the AMUS and MUSOR hardware, and the AMUS computer programs. He interfaced a prototype AMUS microprocessor system with the NTSU timesharing BASIC (Hewlett-Packard 2000 Access System) in August, 1977, to provide a means of storing the software, lessons, scores and student data.

Richard Hamilton developed the timesharing software and Rosemary Killam. under the direction of Robert Ottman. developed the ear-training curriculum. First student use began in September, 1977. The members of one freshman ear-training class were each given one-half hour per week of ear-training drill and practice. They were matched with a control section which received no CAI; by mid-term the class using CAI had a median grade which was 20 points higher than that of the control group.

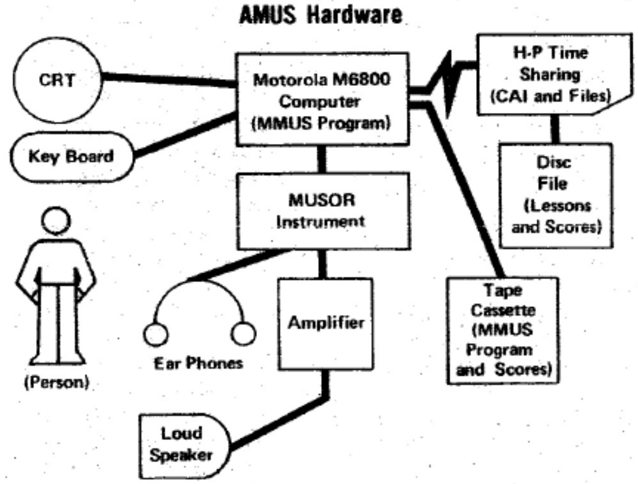
The prototype AMUS system was moved to the music complex for the 1978 spring semester, and its use was opened to all freshman ear-training students, still limited to one-half hour a week per student.

In November, 1978, the ear-training CAI lab was opened with four terminals, as a part of the Computer Sciences Department computer terminal room (this room is also referred to as the Microprocessor Laboratory). Members of all freshman and sophomore ear-training classes (more than 600 students) were allowed to schedule up to three half-hour sessions per week in the lab. A total of eight terminals became available for the spring semester, 1979. In addition other AMUS systems are available for advanced work, and one system is to be installed in an NTSU undergraduate dormitory.

System Description

Several design considerations influenced the development of AMUS. The most important of these was the desire to find a viable middle ground between the very elaborate systems which were too expensive, and affordable systems which were too limited. AMUS is moderately affordable and moderately sophisticated. In the AMUS system the hardware sound generator (called MUSOR) handles the details of performance, i.e., the actual generation of analog voltages by means of digital-logic techniques. A microcomputer (a Motorola M6800) controls the sound on a macro level, determining duration and entry times, pitches, amplitudes, and envelopes of the notes during performance. The microprocessor accepts scores transcribed in the AMUS notation and translates the information into the performance format required by MUSOR. The system configuration is illustrated below.

AMUS Hardware



MUSOR contains a maximum of eight independent voice synthesizers, each with an individually definable waveform which is fixed by the instrument maker but may be different for each voice. (The waveforms are mostly odd harmonics.) This hardware design decision limits the available waveform characteristics, but does not unduly restrict the available timbres and makes possible considerable economies in hardware construction. Each voice synthesizer has independent vibrato and tremolo generators.

The design of MUSOR provides the flexibility necessary to serve a variety of users. MUSOR can be configured with a wide range of optional control features (3). The design approach allows an economical minimum configuration to be used for instruction in ear-training and a more expensive maximum version, utilizing the same microprocessor and programs, to be used for other applications. The MUSOR hardware implementation also takes advantage of design idiosyncrasies, i.e., features such as vibrato and envelope decay which are easily and inexpensively added because of the nature of the hardware.

Another important consideration in the AMUS design was the development of a versatile, readable, user-oriented score language. The score information needed to be entered, displayed, edited, stored and created by a variety of terminals and computer systems. In particular, the use of inexpensive terminals and standard BASIC (a programming language) had to be practical. In the models of AMUS so far constructed, a cathode ray tube (CRT) terminal is used together with a Hewlett-Packard BASIC timesharing system.

The AMUS score language is best suited for multiple-part note-oriented music using the equal tempered scale and conventional rhythmic values (4). However, the user can define alternate tunings with accuracy or can specify pitch parameters directly. Global values for articulation, scale, transposition, and metronome markings allow simple coding and easy modification. The score language allows a great deal of detailed control when desired, but it also provides a large number of automatic default values to simplify encoding. When values different than the defaults are necessary, the user may give the value for an individual note or may give the value which is to apply to all the following notes in the AMUS score.

Method of Development of Usage

The method of CAI development chosen at NTSU has been first to determine the ear-training skill areas covered in a semester's course. The curriculum for the semester is planned and the necessary CAI lessons are encoded, debugged, and placed into student use. At the end of each semester's use, the curriculum is reviewed informally. Inevitably, additional lessons are found necessary to augment some skill areas, and existing lessons usually need some revision. Also, the lessons in a given skill area may need to be resequenced and renumbered. This work must take place between semesters. During a semester the curriculum used by students in the lab is kept stable, since any major changes complicate statistical analysis of student progress.

Typical lesson development proceeds as follows: the curriculum to be covered is discussed with Dr. Ottman, e.g. modulation to closely related keys. The presentation of modulatory skills was designed for a series of lessons, each devoted to one modulation from either major or minor to a given key area, for a total of ten lessons. Dr. Ottman wrote a series of modulatory examples for each lesson. The modulation examples written by Dr. Ottman were copied and the originals filed in a curriculum notebook.

Copies of lessons are assigned to volunteers trained to use the encoding system and the lesson editor. Each lesson is given a temporary name, and that name is recorded on the original filed in the curriculum notebook.A file given the temporary name is created for each lesson. One account with a large amount of file space is maintained on the Hewlett-Packard; all completed lessons, and lessons in progress reside there.

The person in charge of a given lesson uses the first ten lines of coding for documentation: when and by whom the encoding was started, if a previous lesson format is used. The lesson author encodes the examples, making any slight modifications required by the AMUS system. Approximately 200 lines are left blank between the documentation and the first example. The author checks his musical encoding and gives a printout of the results to Dr. Killam. She inserts the explanatory text or plans its format with the student author, who inserts the text.

After the lesson is completed and checked, it is renamed to fit the lesson sequence. The new name is added to the list of lessons which CAI users can access, and the new name and the date of its addition to the curriculum are inserted in the first ten lines of documentation. (Subsequent revisions and the name of the individual revising the lesson are also noted in the first ten lines).

Thus, a continuous record of development and expansion is maintained, which is very useful in preparing a review of the CAI material or in planning an extensive addition to the system.

CAI Lesson Construction

The following lesson format has proved successful:

1. opening statement of lesson's purpose;
2. explanation of any new symbols needed by student to use the lesson, e.g. in the case of modulation, the student needs the "=" sign to indicate pivot chords;
3. sample problem played, with correct answer displayed to student;
4. review of student entry procedures;
5. lesson problems.

The lessons are presented to the student through a set of programs collectively termed the curriculum driver. The driver allows a variety of formats to be specified by the lesson authors for any lessons. The author may choose to use traditional musical notation on the screen, either as material displayed to the student or as a part of the student answer format (5).

Problems contained in any given lesson may be presented in the following ways:

1. Problems proceed sequentially through a specified set of graduated difficulty. In this case the student receives no completion message until he has completed the entire set.
2. Problems may be randomly accessed from a list;
   a. an absolute number of correct first answers may be required for completion of the lesson;
   b. a percentage of correct first answers may be specified for completion. The percentage is specified as a fraction, e.g. four out of five, or more frequently, nine out of ten. In the latter case, the program checks the student's progress every ten questions. When the student answers nine of the ten correctly with his first answer, the program gives the student a completion message (4).

Use of CAI by Students

The undergraduates using the CAI system are introduced to it with the aid of a variety of materials. Introductory field trips to the lab are conducted by the music monitors for classes in which the majority of the members have not previously used the system. A handout summarizing student system use is given to all field trip participants.

New students not included in field trips may schedule an individual viewing of a tape and slide show which explains the system; this is housed in the Media Library in the General Academic Building.

Actual student system use begins with sign-on, by first name and social security number. The student is then prompted by the system to schedule sessions. At any sign-on, the student may schedule up to three half-hour sessions during the coming week — times he may keep through the entire semester so long as he arrives promptly for each session. He may check the system schedule to see when time is available, then change, add or cancel sessions. If he is satisfied with his current schedule, he may bypass the scheduling option, and proceed to the lessons or to a lesson listing feature. The student may check a list of lessons available by typing "//L"; he may check a particular curriculum area, or the entire list.

After checking the lessons available (which is also optional) the student selects the lesson on which he wished to work. First-time users are recommended to take an introductory lesson, which presents the overall lesson format and basic user commands (summarized on the handout which is kept beside the terminal).

Although lessons are named and listed in approximate order of difficulty, the student may sequence lessons in any order he wishes. He may repeat any lesson, even if he has previously successfully completed it.

Each lesson contains specifications of the number of times the student may attempt to answer problems. If the student does not give the correct answer within the specified number of attempts the program gives him the correct answer and proceeds to another question. In any lesson, the student may request repetition of the musical example as many times as he wishes.

If, after the introductory portion of the lesson, the student is unsure of the answer format, he may type "//H", which reviews the question and answer format of that lesson. The student may stop any lesson at any point past the lesson's introduction; he may then choose another lesson or end the session. The program records the last lesson which the student uses during a session, and asks if he wants to begin there, at the start of his next session.

The computer is programmed to prepare a weekly summary of lessons used by the students in each ear-training class, and the summary is sent to the class' instructor. The summary shows the students' percentage of correct first answers for each lesson used, and indicates whether the lesson was completed successfully.

Current Status

The current system is maintained and expanded by a large number of people serving in a variety of roles.

Dr. Scott oversees design expansion and modification of MUSOR and AMUS. Under his direction, Mr. John Giles, staff electronic engineer for the Computer Sciences Department, supervises implementation of design. He is assisted by technicians employed by the Computer Sciences Department.

Dr. Killam is responsible for the coordination of music CAI developments. She initiates curriculum development under Dr. Ottman's supervision. As of January, 1979, Mr. Steven Bertsche, teaching fellow in music theory, has assumed responsibility for CAI software development.

The music CAI lab is located temporarily in the NTSU Computer Sciences Department computer terminal room in the General Academic Building. Mr. Donald Retzlaff, a Computer Sciences Dept. instructor, is in charge of the entire Microprocessor Lab; Mr. Douglas Ray, masters candidate in music composition, is the chief ear-training lab monitor, assisted by two other graduate student monitors. Total music monitor time is currently 36 hours a week, with the remaining hours covered by monitors from the Computer Sciences Department.

An informal research group of approximately ten people concerned with research and development of the music CAI system has evolved. The group meets weekly to discuss new developments and to determine means by which they may assist each other's work. A great deal of unpaid volunteer work on the CAI system is done by members of this group, who have been an integral part of system development.

Current planned curriculum developments are listed below in order of their priority:

1. completion of the entire two-year ear-training sequence;
2. completion of a scale and key signature test to be used as both drill and practice and a competence requirement for all first year music theory students.
3. development of curricula to augment and gradually replace the one-semester music fundamentals course required of music majors who are not prepared to enter the music theory sequence;
4. development of sample sets of pre-college music fundamentals and ear-training skills CAI curriculum;
5. development of a course which will train music educators to use the AMUS system and to construct music CAI packages structured to their needs.

Summary and Prospects

The projects described in this paper have been developed from a central philosophy: the art of the possible. All of Dr. Scott's complex hardware is constructed from "off the shelf" parts.

The terminals used are inexpensive and commercially available. AMUS is interfaced to an HP-2000 Access System, which was owned by NTSU before the music CAI development, and is used extensively for other purposes by the university community. The CAI curriculum has been designed to implement the theory pedagogy view already successfully employed by the NTSU School of Music, and has been developed in semester sequences. The entire CAI structure has been developed to be maximally flexible and accessible to a large number of students (in the case of the NTSU School of Music, a minimum of 600 students enrolled in the first four semesters of ear-training).

Wherever possible the computer is used for a variety of tasks peripheral to actual instruction. Student enrollment and session scheduling are done on the system. Extensive student data are kept by the system and regular student progress summaries are formulated and made available.

Computer time is regarded as a valuable resource, and student introduction to the system is augmented by trained monitors, printed handouts and by other audiovisual technology.

A variety of system developments are currently planned. The curriculum driver is being expanded to allow messages to be sent to all CAI users, pointing out new curriculum, any new system developments or scheduling changes. Users will be able to send comments or questions about the system back to a central file where they can be reviewed and answered as needed. A feature will be added so that ear-training users may alter the tempo of musical problems. Unfortunately, funds do not presently permit the redesign and development of the system in a form permitting its implementation outside of NTSU.

In summary, the NTSU Computer Sciences Department AMUS system has enabled the School of Music to develop a multi-faceted project utilizing computer technology to augment music composition, instruction and research.

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