

University of Illinois -- Project EXCEL

Project: Musical Acoustics Demonstration and Instruction

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Project Objectives

Our goal was to develop an IBM PC AT into a mobile station for demonstration and instruction of musical acoustics phenomena. The primary course to benefit from this equipment was to be Music 302 (musical acoustics), although other courses in the School of Music, such as Music 448 (computer music) and in the Department of Electrical and Computer Engineering, such as EE 302 (electronic music synthesis) and EE 303 (topics in audio) could benefit. We decided to implement a series of five demonstrations in an attempt to enhance the students' ability to visualize and grasp various acoustics concepts. The first trial was for Music 302 during the spring, 1986 semester.

The demonstrations we decided to implement corresponded to different segments of the musical acoustics course. They are:

- 1) Wave propagation/reflection on vibrating string and acoustic pipe. (utilizing animated color graphics)
- 2) Waveform/spectrum synthesis from Fourier amplitudes and phases. (graphics plus sound output)
- 3) Waveform analysis (graphics plus sound input).
- 4) Modal patterns of square and circular membranes (color three dimensional graphics with some animation).
- 5) Comparison of scale tunings (sound output).

We also wanted to set up an efficient programming environment on the AT so that it would be relatively easy to develop new demonstrations.

Implementation

This project was implemented on three fronts: hardware organization, software organization, and lesson design.

The hardware includes IBM-supplied items and equipment from other vendors. In particular, the demonstration/analysis apparatus consists of an IBM PC-AT with several internal hardware expansion boards and peripheral equipment. At this time, the PC-AT is equipped with:

- 1640KB of RAM
- 80287 math co-processor

- 2 20MB fixed disks
- 1.2MB floppy drive
- IBM Professional Graphics Controller (PGC) and Display
- MetraByte Corp. DASH-16 high-speed 12-bit analog/digital/analog data acquisition board with direct memory access capability
- Ariel Corp. fast Fourier transform (FFT) co-processor board, also with DMA capability
- 2 serial/parallel adapter ports
- 6-pen IBM 7372 color plotter
- Mouse Systems optical mouse
- IBM Proprinter with graphics capability

Recent additions to the demonstration system include:

- Octave Plateau OP-4001 Intelligent MIDI Interface board
- Ariel Corp. DSP-16 16-bit analog/digital/analog board with 256K sample buffer memory and TMS32020 digital signal processing chip.

This new hardware will be utilized to enhance existing demonstrations and in the development of new software.

The entire system is self-contained, and can be transported to and from any classroom in the music building using one medium-sized cart.

The range of input and output devices and the need for a simple and reliable "user interface" proved challenging for our software development. Other than some low-level device control routines and utility libraries, all of the control software was designed and implemented from the top on down. The bulk of the software was written in the language C using the Lattice compiler. High-level graphics functions are accomplished using the IBM C-language binding for the Graphical Kernel System (GKS), and device drivers of the Virtual Device Interface (VDI). Software requiring high performance, such as real-time digital sampling and analysis or fast animated graphics, was written in assembly language using the IBM Macro Assembler. The core of the software was written between November, 1985 and June, 1986 with changes and revisions occurring up to the present time. Most of the software exploits the device-independence of the VDI, so hardcopy output of on-screen demonstrations is available using the pen plotter or printer. Some of the demonstrations require direct access to the features of the Professional Graphics Controller and display. These demonstrations make use of filled regions or animation, so no hardcopies are obtained.

In the future we expect to develop several demonstrations using the OP-4001 board as a connection to synthesizers and other equipment supporting the Musical Instrument Digital Interface standard, known as MIDI. The flexibility of the configuration should provide for the development of additional graphics and sound demonstrations. At present, Roger Dannenberg's Carnegie-Mellon MIDI Toolkit software is installed on the AT for experiments and program development. Additional work will be accomplished using the Ariel DSP-16 hardware for direct-to-disk digital recording and playback, signal processing, and sound analysis.

Project Significance

We feel that several features of this project are particularly significant:

The use of three-dimensional animated graphics is somewhat unusual for classroom demonstrations. Where there was once only chalkboard sketches or diagrams in a textbook, the computer and graphics display enable a clearer visualization of membrane vibrational modes.

To our knowledge, this project is the only one on campus using a combination of graphics and audio input/output. It is clear that demonstration of acoustic phenomena should include acoustical examples. In the past, many of the examples were on cassette tape, and suffered from various degradations in quality. Some of these examples are now generated "brand new" each time via digital means.

The use of a computer to assist in the teaching of introductory musical acoustics is itself rather novel. While a well-stocked and well-maintained inventory of various musical instruments, analyzers, and playback devices would be ideal, monetary and storage space constraints make the flexible and portable PC-AT-based analysis and demonstration system an effective alternative.

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