A Software "Teacher" for Acoustical Measurements

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Abstract: "A Simple Loudspeaker Measurement Program" is a Computer Based Education (CBE) application for self-studying of acoustical measurements. The application deals with free field measurements of loudspeakers and related theory. The measurements are made with the program and genuine results are achieved each time. The application is designed for educational purposes, but can be used also by engineers, technicians etc. for "assisted" measurements.

COMPUTER BASED EDUCATION

Computer Based Education (CBE) means using computers to help educate students. Computers can be used in any thinkable way, but CBE usually refers to programs or applications designed to teach students by themselves, without consistent help of a human supervisor.

The huge development in computer technology, especially in the field of multimedia features and computational power, has made it tempting to use computers also in acoustics education. Computers are already basic tools in acoustics and digital signal processing (DSP). Thus it is only natural to start applying them as a tool for education. Using a computer as a teacher requires a simple and easy to learn user interface, good graphics and sound handling capabilities, and a powerful enough processor to provide the speed that is essential to keep up the interest of the student. Interactivity and hypermedia environments are usually heavily exploited (1). Even personal computers (PC's) of today are capable to provide qualities to do all this and it is left to the programmer's ability to take full use of the computer's power.

TECHNICAL DESCRIPTION OF THE SYSTEM

The system consist of a computer, an audio amplifier for the loudspeaker, the loudspeaker to be measured, a microphone, a microphone amplifier and preferably an anechoic chamber. QuickSig (2) is an object-oriented Common Lisp (3) based signal processing environment developed by the Laboratory of Acoustics and Audio Signal Processing at the Helsinki University of Technology. QuickSig provides excellent means to present graphics, handle signals, and it is easy to program for educational purposes as well. Installed on the computer, QuickSig generates all stimuli, converts them to analog signals and sends them to the loudspeaker through the audio amplifier. The microphone captures the response of the loudspeaker and the response arrives back to the computer via the microphone amplifier. The computer converts the analog response back to digital format and the desired results can be computed and presented. All signal processing is performed digitally by QuickSig. The loudspeaker and the microphone are placed in an anechoic chamber to prevent room reflections to interfere the results. A normal room could also be used, but this requires time windowing of the results and could restrict the useful frequency range.

"A SIMPLE LOUDSPEAKER MEASUREMENT PROGRAM"

The application can be divided into three main parts: the starting pages, the theory pages and the measurement pages. The starting pages consist of general information, a short guideline on how to use the program, a brief introduction to the contents of the program and instructions on how to set up the measurement system. There is also a basic test which ensures that the student has made the measurement setup properly. Theory pages provide the theory related to measuring equipment, loudspeakers, measuring techniques and the environment (4).

Theory pages can be kept open during the measurements, read before the measurements, or they can be skipped completely. The program does not control that the student has studied the theory pages, yet they may contain essential information considering the questions during the measurements.

The measurement pages introduce the real measurements (Fig. 1) which the student performs with the aid of the computer. Usually a loudspeaker is the object to be measured, but other sound sources could be measured as well. Measurements include main axis free field response, free field response from different angles (directivity), free field response with one reflecting surface (floor), harmonic distortion, sensitivity, and group delay of the loudspeaker. The loudspeaker to be measured can be any ordinary loudspeaker. During the measurements the student is faced with different kind of questions he or she must answer to advance to the next measurement. All questions and answers are saved to disk and a paper copy of them can be printed for later discussion. Simple questions, such as multiple-choice questions are checked by the computer directly and if more complex questions are presented they can be checked by the course assistant later. All measurement results and graphs can also be saved and printed if necessary. The program doesn't prevent the student's advance to the next measurement on the basis of wrong answers; the final judgment is done by the course assistant. All different parts of measurement pages can be viewed as individual measurements and accessed individually. They don't rely on other measurements and the succession of pages can be chosen by the student. The program provides immediate feedback for the student right after the measurements when the questions and answers are still clearly on mind.

The application is intended to be a tutorial level education program. It illustrates how the theory fits in real audio measurements and combines theory with practice. The application presents true interactivity and its goal is to teach understanding of loudspeaker measurements in contrary to typical online help system of an audio measurement program.

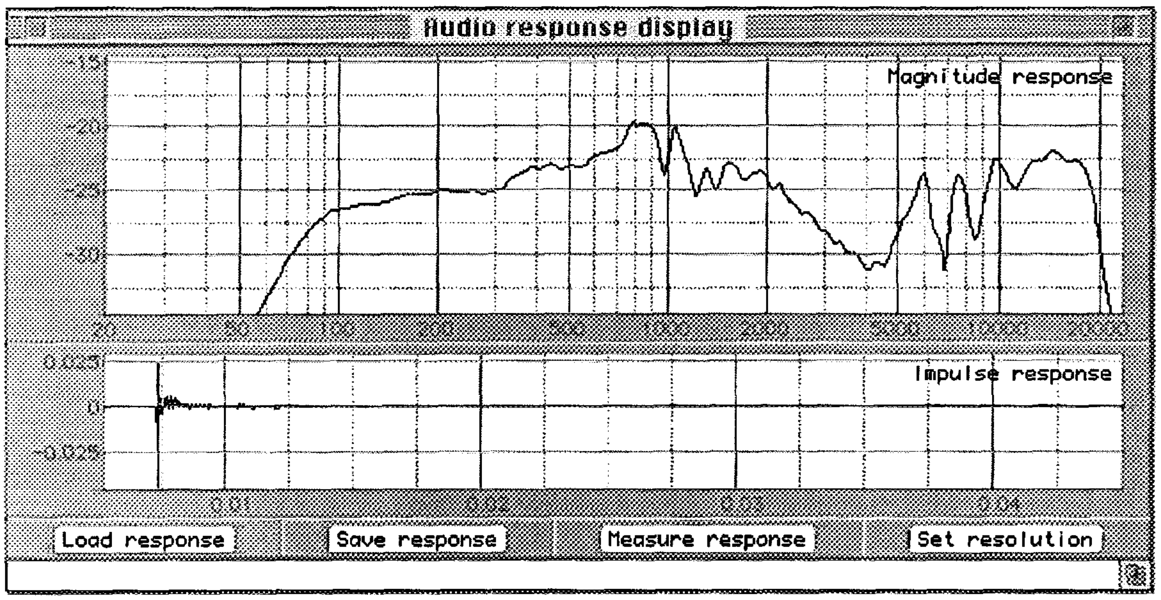

FIGURE 1. Measured free field magnitude response of a loudspeaker and the corresponding impulse response as shown on a typical measurement page.

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