Introduction of a Laboratory Technical Acoustics at Heilbronn University (Germany)

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Introduction

Heilbronn University (aka Heilbronn University of Applied Sciences) ranks with approximately 5300 students, 172 professors, 66 researchers and 21 research assistants (as of March 2009) amongst the major institutions of higher education in the federal state of Baden-Württemberg in Germany.

Due to the abolishment of diploma degree programmes along with the introduction of bachelor and master degree programmes during the Bologna process, the higher education system had to be rearranged to standardized requirements.

This progress was responsible for the development of appropriate courses so that the education in acoustics is currently enjoying a renaissance at Heilbronn University. In this context, our roots of teaching in acoustics go back to Prof. Dr. Ulrich Arns (emeritus since 1989), who was the initiator of all acoustic activities in former times.

For summer semester 2009, the acoustic course offer has been expanded by adding a laboratory technical acoustics, with the most important facts being presented in this paper briefly.

Prerequisites

The current lecture technical acoustics with 2 ECTS is based on the concept of Dipl.-Ing. (FH) Uwe Riedel, development engineer specialized in electro-acoustics from Ehmann & Partner GmbH [1]. For upcoming semesters, the scientific teaching assignment will be continued by Dipl.-Ing. (FH) Gerald Landstorfer, external PhD-Student at Slovak University of Technology [2].

According to study and examination regulations, the course is offered in the sixth semester. Furthermore, it is classified as an optional subject within all degree programmes of the Department of Mechanics and Electronics, namely Automotive Systems Engineering, Electrical Engineering & Information Technology, Mechanical Engineering, Mechatronics & Micro System Engineering and Robotics & Automation.

The number of participants of the past semesters showed that the lecture averaged a number of 20 students per winter semester.

From the acoustic point of view, the main focus of the course [3] coincides with the demanded minimum canon by the DEGA for a two hour acoustic lecture in bachelor degree programmes [4].

The evidence of academic achievement is ensured by a 90-minutes written exam at the end of the semester, containing both theoretical questions and mathematical calculations.

Requirements

Due to study and examination regulations, the laboratory technical acoustics with 3 ECTS is offered in the seventh semester within all degree programmes of the Department of Mechanics & Electronics.

The basic concept is to achieve the following aims:

- The students' comprehension of basic acoustical phenomena shall be a focus.
- The experiments shall deal with actual problems close to our areas of research, as well as general tasks given from surrounding industrial companies.
- The expansion of knowledge in our core competence fields with student support in projects, bachelor or master thesis'.
- The laboratory timetable shall also consider the possibility of a field excursion to one of the several industrial companies with acoustic background per summer semester.

As part of an advertising campaign, on the one hand the internet presence of the acoustic course offer was expanded by two informative wiki homepages [3], [5] as central information platform for motivated students. On the other hand, the implementation of university-based information about the education in acoustics in nationwide [6] and even Europe-wide [7] online study guides will also increase the acoustic degree of popularity at Heilbronn University.

According to the number of expecting participants in conjunction with available locations (anechoic measuring room, jury test room, corridor with reverberation properties, auditorium, laboratory electronic circuit technology), groups of two or three students may work for their own on a total number of six different experiments.

Due to these circumstances, the laboratory instrumentation had to be completely renewed, with a certain part of the laboratory equipment having been funded by tuition fees. Further laboratory depending materials (e. g. experiment descriptions or laboratory regulations) were listed and will be handed out at the beginning of the course.

The mentoring of the student groups is carried out by the authors mentioned above. However, the experimental procedure is participants-oriented, focussing on personal abilities e. g. independence, personal initiative, creativity and mental mobility.

Taking all facts of the laboratory strategy into consideration, it will make sense to correlate the topics of the laboratory with the topics of the lecture.

Laboratory experiments

Anti-sound noise cancellation

Figure 1: Rectangular duct in y-shape made from plexiglas with according signal processing (Pure Data), playback (4“ mid-range transducer with amplifier), recording (electret condenser microphone capsules) and visualisation (oscilloscope) hardware.

Preparation and measuring tasks

- Proof of the properties of the duct with rectangular cross-section with opened and closed end (e. g. standing waves or resonance frequencies).
- Combination of original and contrary sound waves (identical amplitude but opposite polarity) for noise reduction by destructive interference.

Multi-channel playback and recording

Figure 2: Stereo triangle configuration with a linear loudspeaker array of eight JBL Control 1 monitor loudspeaker and head and torso dummy from HEAD acoustics in our jury test room. Further necessary equipment, e. g. amplifier and RME Hammerfall audio interfaces is in the anteroom.

Preparation and measuring tasks

- Geometrical modelling of a one-dimensional loudspeaker array in consideration of acoustic aspects.
- Realisation of intelligent playback configurations with Matlab (e. g. constant phase shift between the loudspeaker boxes) and following metrological evaluations (interaurale level and time differences).

Metrological investigation of loudspeaker parameters

Figure 3: Experimental set-up consisting of B&C compression drivers with d&b horn prototypes, Outline ST 1 turntable and measuring microphone in our anechoic measuring room. This equipment is controlled by the Digital Audio Analysis Software (DAAS) and Outline controller ET 1 which can be found in the side room.

Preparation and measuring tasks

- Familiarisation with the whole functional range of the acoustic measuring system and the objects.
- Measurement and comparison of three different horn loudspeaker characteristics (i. e. complex frequency response, impedance, step and impulse response and dispersion characteristics after DIN EN 60268-5).

Acoustic specification of various closed rooms

Figure 4: Dodecahedron with amplifier and appropriate portable measuring instrumentation (laptop, Acoustilyzer NTI AL1 with MiniSPL) for reverberation time measurements in different university-intern lecture rooms.

Preparation and measuring tasks

- Measurement and interpretation of reverberation time in different rooms according to their usage (DIN EN ISO 3382).
- Qualification tests of acoustic properties of rooms in regard to speech intelligibility with logatoms (DIN 18041).

Acoustic quality assurance of electric motors

Figure 5: Airborne sound / solid-borne sound measurements (microphone / accelerometer) of electric motors from Nidec that have different implemented definite defects.

Preparation and measuring tasks

- Repetition of the fundamentals of digital signal processing (i. e. Fourier transformation (FFT, DFT), Shannon sampling theorem and window functions).
- Comparison of airborne sound and solid-borne sound spectra with assignment of the characteristic frequency lines to relevant cause of damages (e. g. defective ball bearings and unbalanced spindles).

Psychoacoustic hearing phenomena

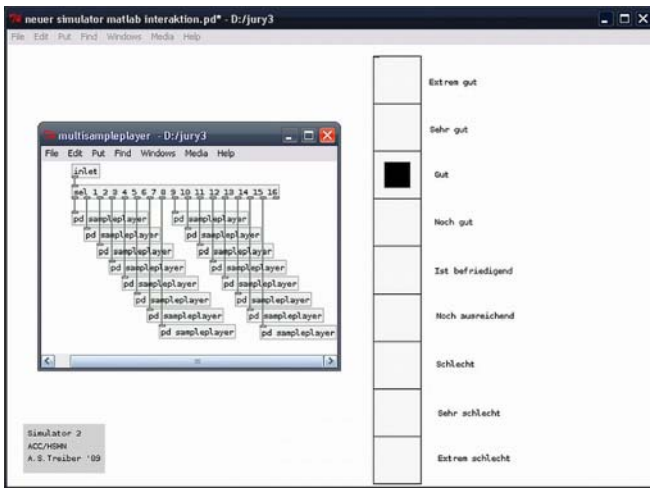

Figure 6: PC headphone playback of selected psychoacoustic experiments based on appropriate Pure Data patches.

Preparation and measuring tasks

- Overview of the most common psychoacoustic scales (e. g. roughness, loudness or pitch) as well as the methods used to obtain these scales (i. e. magnitude estimation and forced-choice procedures).
- Arise of awareness of different psychoacoustic issues i .e. temporal / spectral masking, individual threshold detection, sensation of loudness in control of frequency, duration and amplitude of a stimulus.

The evidence of academic achievement is based on the quality of the individual laboratory reports that must be handed in before the beginning of the next practical task. Nevertheless, specific introductory questions shall check the students' level of preparation in order to ensure an unproblematic and safe experimental procedure.

Summary

With the introduction of a laboratory technical acoustics, the expansion of the acoustic course offer at Heilbronn University was completed. From now on, the teaching in acoustics combines both theoretical knowledge and experimental lab work, which provides the basis for qualified specialists.

In conclusion, the lecture teaches the fundamentals of technical acoustics. The students will be able to develop a comprehension for important acoustic phenomena. Moreover, they will get a first access to acoustic recording and playback techniques, as well as to psychoacoustics, room acoustics and acoustic measuring technology.

Finally, the students will have to deal with different metrological tasks of technical acoustics within the laboratory. They will learn to use standard hardware e. g. portable measuring instruments as well as special PC-based software and measuring systems. Furthermore, the students will get to know different measurement methods in order to create a basic knowledge for acoustic problems and its solutions.

Acknowledgements

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