Training and Guidance Tool for Listening Panels

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Introduction

The interest in assessing and quantifying the acoustical properties of technical products has been increasing during the last years. This applies also to non-audio products. Despite there being several methods for the objective evaluation, that are based on models of the human auditory perception, they can only treat a limited number of application areas reliably [1]. Therefore listening tests have to be performed that deliver reliable and repeatable results. However, they require a large number of subjects from the target groups. As this approach costs a lot of time and money, it is preferable to employ a well trained and properly selected expert listening panel (ELP), which ensures consistent vocabulary usage and reliable rating behavior. Even with the reduced number of subjects, reliable and satisfying statistical conditions can be obtained and this will save both, money and time. Within a research project, an ELP has been recruited [2] at the institution of the authors. This project lasts several years and treats pure research questions up to product benchmarking. Training is necessary to maintain and improve the performance and sensitivity of the ELP members. In this paper we present an expandable computer-based training application, which treats general training as well as specific preliminary tests.

Existing training tools

There are commercial training tools available, e.g. [3, 4], which cater to the naive listener up to the more advanced listener. As all stimuli are provided on compact discs, no computer is needed for the training. But using no computer has the disadvantage that randomization, double-blind comparisons, automatic statistical analysis and the synthesis of new stimuli (e.g. for more advanced skill levels) are not possible. Besides, the costs of providing individual copies for all ELP members would be expensive.
Proprietary training tools often use a computer for controlling the test sequence but the signal processing is done by outboard equipment (e.g. parametric equalizers) [5, 6]. While this solutions are more flexible in terms of different skill levels, they still need expensive hardware.
One of the first truly computer-based tools [7] gets rid of this costs by doing all signal processing on the users computer. Unfortunately, this application is not available for sale and is not easily expandable with new exercises.
In order to overcome the restrictions of existing training tools, we define several demands on the software tool.

Demands on the software tool

In the beginning of the development process, the following demands have been made on the software tool. It is expected to provide:

- inexpensive and easy usage for ELP members
- minimization of required disk space
- different skill levels
- build-in statistical analysis
- easy and secure transfer of user data
- easily expandable with new exercises.

The usage of open-source software and stand-alone applications provides inexpensive usage at the ELP member site. The software runs on personal computers with standard hardware on 32 and 64 Bit Windows systems (it has also been successfully tested on Mac OSX using virtualization software). The user interface is laid out as uniformly as possible and is maintained for the listening tests of the project.
The computation of the stimuli is done in real time. This avoids the need of large libraries of pre-processed sound files and reduces the required disk space.
In order to motivate the ELP members, the training exercises are organized in different skill levels with a defined threshold to unlock the next level.
The software is capable of doing all required statistical analysis, so that the amount of data monitored by the supervisor is minimized.
All user data (e.g. achieved levels, training time) is saved in one encrypted file per user and be fully transferable to other systems and to the supervisor for monitoring the individual progress.
The biggest benefit compared to existing solutions is the expandability of our software tool. It can easily be customized for new exercises and serves as preliminary tests for upcoming experiments in the research project. This can be achieved by the layout of the software.

Software layout

Our training and guidance tool is modular structured software (see figure 1), so that different parts can be updated independently.
The core program controls the complete test sequence, file-handling and communication between all different parts. This part is programmed in Matlab [8] and compiled as a stand-alone application. This application does not need a Matlab license, but the matlab compiler runtime, which can be distributed freely.

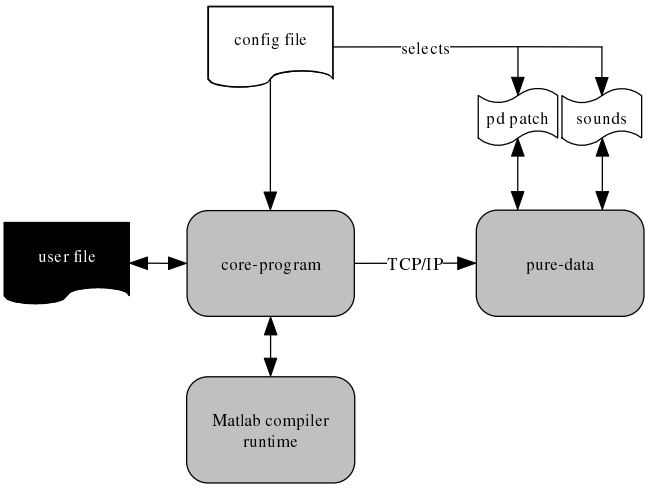

Figure 1: Layout of the training software: gray blocks have to be installed once, white blocks are updated for every new exercise, the black faced user-file is updated during runtime.

The entire signal processing, like filtering or loudness modification, is done in real time using a precompiled version of pure-data (pd) [9], an open-source software. The communication between the core program and pd is realized through a TCP/IP connection. The above mentioned parts of the software (gray blocks in figure 1) require a large amount of disk space, but have to be installed only once or updated if the new features like other test paradigms have to be included into the core program.
New exercises assigned to the ELP only consist of a configuration file, a patch file for pd, and raw sound files (white blocks in figure 1). The configuration file contains all information for the setup of the experiment, such as test paradigm, parameters for each level, threshold for next level, description, number of trials, used pd patch file, and sound files.
The achieved level for each experiment is read from the user file (black block in figure 1) at startup. After an exercise, the corresponding level is updated. Additionally, the time needed for the experiment is saved in this file. This file can be transfered and used on other systems. The data in this file is encrypted.

Exercises

As general training, our software provides exercises for loudness and timbre discrimination. The loudness discrimination offers 10 skill levels classified in steps of $10 \ldots 0.1$ dB. The timbre discrimination also provides 10 skill levels classified by Q-factors in steps of $0.5 \ldots 5$ and gains of $\pm 10 \ldots \pm 1$ dB for different center frequencies. The exercises may use synthesized sines, noise signals, as well as arbitrary sound files. For the playback, there are two different modes available: either the user is forced to listen to every stimulus in its full length or the user can switch between the stimuli during playback. In the first case, the users memory for auditive parameters can be trained, too.
Furthermore, exercises might serve as specific preliminary tests: e.g. the audibility threshold of artifacts using particular codecs with different audio recordings.
At the moment, all exercises use a triangle-test paradigm [10]. Three stimuli are presented, whereof two are identical and one differs from those two. The subject has to choose the odd one out. The probability of making the right decision by chance decreases to 33% compared to 50% in standard AB or ABX. In this way, the number of trials or the threshold for the next level can be reduced. The playback loudness can either be set to a comfortable level or adapted to the hearing threshold. As this threshold does not differ much between the ELP members [2], the playback conditions are similar for all members.

Conclusion

This paper presented the features of our training and guidance tool for an established expert listening panel. The proposed application has already been in use for half a year and treats general training as well as specific preliminary tests.
In further development, the core program will be upgraded with more test paradigms to increase the flexibility. Moreover, the expansion with new exercises and preliminary tests is in progress.

Acknowledgments

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