Appendix E

Audio Recording Tools

The following sections present some technical details of the tools and methods provided by the Active Recording components described in Chapter 7.

E.1 VU Meter

The VU meter is still the most basic tool for measuring the input gain, and was originally standardized by IEC 268-10:1974. E-Chalk's VU meter is implemented as an independent SOPA node and is integrated by default in the audio wizard and the default audio processing graph. However, it is only provided as a debugging tool. During a real lecture, the movement of the meter bars would be too distracting for the students. E-Chalk's VU meter displays both the peak signal and the average signal level. It also counts overruns (an overrun is defined to occur when the signal reaches more than 98 % of the maximum allowed range). The average gain level is measured by calculating the root-mean-square value of a time window of 250 ms. The value ages with the last three measurements. The ideal recording maximizes the average signal without causing overrun. Figure E.1 shows a screenshot of E-Chalk's VU meter.

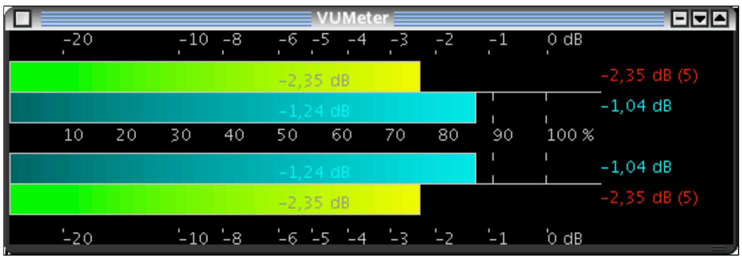

Figure E.1: A screenshot of E-Chalk Audio's VU meter. This view shows the VU meter in stereo mode with a mono signal fed in. The inner bars show the average gain while the outer bars show the peak gain. Overflows are counted and displayed in red next to the peak gain meter.

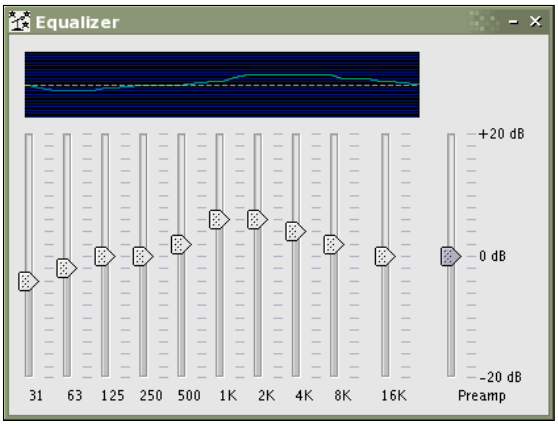

Figure E.2: A screenshot of E-Chalk Audio's equalizer in a typical setting used for enhancing the intelligibility of speech.

E.2 Graphic Equalizer

A graphical equalizer can be used to fine-tune the frequency spectrum of an audio signal. Certain frequency bands can be suppressed or amplified. The equalizer is implemented as a SOPA node and is shown only on request since audio quality can also be easily degraded if used without prior knowledge. By default, the equalizer settings can be adjusted during the simulation step of the audio wizard. E-Chalk's graphical equalizer simulates a 10-band octave filter array conforming to ISO R.266. Equalizer settings can be saved and loaded separately. Figure E.2 shows a screenshot.

E.3 Assessment of the Audibility of Noise

Measuring the floor noise by calculating the root mean square of a few seconds of the signal is only a very rough estimate because the minimum audible sound level is frequency-dependent. The exact frequency/loudness curves have been measured and standardized often, for example by [ISO, 2003]. Ultimately, these curves depend on the listeners's individual anatomy and health status. In order to provide comparable results, signal-to-noise ratio is measured using the A-weighted curve [DIN EN, 2003]. However, for finding out whether a given floor noise is above the hearing threshold, E-Chalk's audio diagnose wizard uses the model proposed by PEAQ [ITU, 2001], which provides a better approximation to the human auditory system. In order to provide a model for the lower auditory threshold, a Discrete Fourier Transform (DFT) of the signal is calculated over 50 % overlapping blocks of 2048 samples, sliced by a Hann-window. The spectrum is then weighted by the following function (outer and middle ear):

$$W[k]/dB = -0.6 \cdot 3.64 \cdot \left(\frac{f[k]}{kHz}\right)^{-0.8} + 6.5 \cdot e^{-0.6\cdot\left(\frac{f[k]}{kHz}-3.3\right)^2} - 10^{-3} \cdot \left(\frac{f[k]}{kHz}\right)^{3.6}$$

with

$$f[k]/Hz = k \cdot 23.4375$$

being the frequency representation at line k that is applied to the DFT output. The minimum auditory threshold is then modelled by adding a basic noise of $0.4 \cdot 3.65 \cdot (f/kHz)^{-0.8}$ (inner ear). Given this modelling of the lower auditory threshold, any signal can be compared to it using spectral subtraction.

E.4 Equipment Grading

The audio system is graded based on the silence noise levels measured for sound card and equipment and on the speech-level-to-noise ratio. As already discussed in Chapter 7, judging sound card or equipment quality based only on the measurement of floor noise is a very rough approximation. But it is often used because it can easily be measured. The grading scale has been contructed by collecting test results from the Internet. Zero noise level of sound cards are graded as follows (when equipment is connected, the levels are shifted up by 5 dB).

$$category(noiselevel) = \begin{cases} \text{excellent,} & \text{if } noiselevel < -90\,dB \\ \text{good,} & \text{if } noiselevel < -70\,dB \\ \text{sufficient,} & \text{if } noiselevel < -65\,dB \\ \text{scant,} & \text{if } noiselevel < -40\,dB \\ \text{inapplicable,} & \text{if } noiselevel >= -40\,dB \end{cases}$$

The signal-to-noise ratio (SNR) is rated according to the following mapping. As a reference: A modern sound card has a typical SNR of over 100 dB (in 24 bit recording mode), a compact-disc player has a typical SNR of about 80 dB, an analog studio tape recorder has an SNR of about 70 dB, a vinyl disc player of about 60 dB, and shellac discs used to deliver sound with a typical SNR of about 40 dB [Fries and Fries, 2005].

$$category(snr) = \begin{cases} \text{excellent,} & \text{if } snr >= 90\,dB \\ \text{good,} & \text{if } 90 > snr >= 80\,dB \\ \text{sufficient,} & \text{if } 80 > snr >= 50\,dB \\ \text{scant,} & \text{if } 50 > snr >= 40\,dB \\ \text{inapplicable,} & \text{if } snr < 40\,dB \\ \text{improperly measured} & \text{if } snr < 10\,dB \end{cases}$$