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AUDIO DATA HIDING THAT IS ROBUST WITH RESPECT TO AERIAL TRANSMISSION AND SPEECH CODECS

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Abstract. *A technique for audio data hiding by using subband amplitude modulation was evaluated by computer simulations in terms of robustness with respect to the cumulative effects of reverberations, background noise, and encoding and decoding with a speech codec. Speech signals from 22 speakers and signals from 100 pieces of music were used as the host audio data. Computer simulations revealed that speech and music signals with background noise and reverberations were able to transmit at least 80% of the embedded data at 8 bps after encoding and decoding using the Adaptive Multi-Rate (AMR) speech codec at a bitrate of 12.2 kbps. In actual measurements in a reverberant room using a cell phone terminal, data hidden in a 12.2-kbps AMR recording having a signal-to-noise ratio of 20 dB was detected at a mean bit error rate of 15 %. The sound quality degradation induced by data hiding was objectively measured using the perceptual evaluation of speech quality (PESQ) and perceptual evaluation of audio quality (PEAQ) algorithms. The average PESQ score of the speech signals approximately corresponded to a subjective evaluation of 'fair', while the average PEAQ score of the music signals corresponded to a somewhat lower subjective evaluation of 'slightly annoying'.*

Keywords: Acoustic application, Speech codec, Acoustic noise, Telephony, Information system, Microphone

1. **Introduction.** Watermarking technologies are expected to be applied to copyright management, tamper detection and recovery [1] of multimedia data, including images [2] and video [3]. Audio watermarking techniques are usually associated with content protection and digital rights management of music. Another application of audio watermarks is the inclusion of augmentation data [4]. For example, if an announcement broadcast from loudspeakers in a public area contains embedded text, the embedded data can potentially be extracted in real time from the speech signal upon detection by a microphone. Such an application would be invaluable for hearing-impaired people. The signal can be received by a portable device, such as a PDA or a cellular phone. Such an application requires a method of audio data hiding that is robust with respect to reverberations, reflections, and background noise [5].

If a cellular phone is used as a terminal for displaying information, extracting data using the phone would necessitate the installation of additional decoding software that would require excessive processing power. To solve this problem, sounds received by a cellular phone can be transmitted via a cellular network to a server computer for data extraction. The information extracted by the server computer can be transmitted to the cellular phone terminal via e-mail. In this situation, the embedded data should be robust against the speech codecs employed in the cellular network.