Low Delay - Code Excited Linear Predictive (LD-CELP) Coding of Wide Band Speech at 32kbits/sec

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Abstract

We investigate the potential of the Linear Predictive Coding (LPC) based algorithm, Low Delay - Code Excited Linear Prediction (LD-CELP), for coding wide band (.05-7khz) speech at a bit rate of 32kbits/sec. This bit rate allows for stereo transmission of wide band speech over a single 64kbits/sec basic rate ISDN channel, thereby permitting the simultaneous transmission of image data over the other 64kbits/sec channel. The low delay feature makes tele-conferencing and other two way speech communication scenarios particularly inviting applications for this type of coding algorithm.

A simple minded application of the LD-CELP algorithm to wide band speech resulted in audible high frequency distortion with essentially perfect coding at low frequencies. Three approaches to compensating for this frequency asymmetry in coding quality were investigated. The first approach involves simple modifications to the conventional CELP noise weighting filter in an effort to introduce more degrees of freedom, and thereby allow for a more accurate modeling of both spectral tilt and formant structure. The second approach uses a psycho-acoustically based model of human hearing to determine the noise weighting filter. The third approach decomposes the input speech into high and low frequency bands using a quadrature mirror filter bank and applies the LD-CELP algorithm to each band separately. An additional part of the thesis is devoted to improving the efficiency of the CELP codebook design algorithm, which was found to be slow and cumbersome. Two improvements are proposed and evaluated. Finally we present the results of a small-scale, formal, a/b subjective test comparing our best 32kbits/sec LD-CELP system to the 64kbits/sec G.722 CCITT wide band speech coding standard.

The main conclusion of the thesis is that 32kbits/sec high quality coding of wide band speech is definitely viable, and that the basic LD-CELP algorithm along with some improvements suggested in the thesis is an excellent candidate for this application. The subjective test results indicate that the speech qualities of our 32kbits/sec LD-CELP and the 64kbits/sec G.722 are identical.

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