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| Aim: | Speech Compression using µ law and A law companding |
| Apparatus: | MATLAB |
| Prerequisit: | Compression basics, Speech processing |
| Theory: | The simplest way of compressing speech compression using quantization.The goal in any system design is quantizing the data in smallest number of bits that results in a tolerable level of error. In the case of speech coding, linear quantization with 13 bits sampled at 8 KHz is the minimum required to accurately produce a digital representation of the full range of speech signals. For many transmission systems, wired or wireless, 13 bits sampled at 8 KHz is an expensive proposition as far as bandwidth is concerned. To address this constraint, a companding system is often employed.  Companding is simply a system in which information is first compressed, transmitted through a bandwidth limited channel, and expanded at the receiving end. It is frequently used to reduce the bandwidth requirements for transmitting telephone quality speech, by reducing the 13-bit codewords to 8-bit codewords. Two international standards for encoding signal data to 8-bit codes are A-law and m-law. A-law is the accepted European standard, while m-law is the accepted standard in the United States and Japan.  **Speech Companding**  The human auditory system is believed to be a logarithmic process in which high amplitude sounds do not require the same resolution as low amplitude sounds. The human ear is more sensitive to quantization noise in small signals than large signals. A-law and m-law coding apply a logarithmic quantization function to adjust the data resolution in proportion to the level of the input signal. Smaller signals are represented with greater precision – more data bits – than larger signals. The result is fewer bits per sample to maintain an audible signal-to-noise ratio (SNR). The *μ*-law encoder inputs 14-bit samples and outputs 8-bit codewords. The Alaw inputs 13-bit samples and also outputs 8-bit codewords.  **A-Law Compander**  A-law is the CCITT recommended companding standard used across Europe. Limiting the linear sample values to 12 magnitude bits, the A-law compression is defined by Equation given below, where *A* is the compression parameter and *x* is the normalized integer to be compressed.  The encoder uses the logarithmic expression  **sgn(*x*)[ *A|x| / (* 1 + ln(*A*))] *,* for 0 *≤ |x| <* 1/*A*,**  **sgn(*x*)[(1 + ln(*A|x|*))/(1 + ln(*A*))] *,* for 1/*A ≤ |x| <* 1.**  The G.711 standard recommends the use of *A* = 255  ***μ*-law Compander**  The United States and Japan use m-law companding. Limiting the linear sample values to 13 magnitude bits, the m-law compression is defined by Equation 2, where m is the compression parameter (*μ* =255 in the U.S. and Japan) and x is the normalized integer to be compressed.  The encoder uses the logarithmic expression  **sgn(*x*)[(ln(1 + *μ|x|*))/(ln(1 + *μ*))] *,* where sgn(*x*) =+1*, x>*0,**  **0*, x*= 0,**  ***−*1*, x<*0,**  The G.711 standard recommends the use of *μ* =255    The Above Graph shows this output as a function of the input for the three *μ* values 25, 255, and 2555. It is clear that large values of *μ* cause coarser quantization for larger amplitudes. Such values allocate more bits to the smaller, more important, amplitudes. The G.711 standard recommends the use of *μ* = 255. The diagram shows only the nonnegative values of the input (i.e., from 0 to 8191). The negative side of the diagram has the same shape but with negative inputs and outputs.  Hence there is a wide array of audio transmission systems that employ A-law and/or m-law companding for data rate reduction with good audio quality. The compression achieved by both A-law and m-law coding is the result of utilizing the logarithmic characteristics of the human auditory system, where fewer bits of precision are required for larger signals than smaller ones. The logarithmic transfer function is implemented with a piece-wise linear approximation composed of a sign bit, a 3-bit chord, and a 4-bit segment.  Matlab functions used:  1) [index,quants,distor] = quantiz(sig,partition,codebook)  This function returns index which is the the quantization levels in the real vector signal sig using the parameter partition. partition is a real vector whose entries are in strictly ascending order. Codebook prescribes a value for each partition in the quantization and quants contains the quantization of sig based on the quantization levels and prescribed values. codebook is a vector whose length exceeds the length of partition by one. quants is a row vector whose length is the same as the length of sig. quants is related to codebook and index by  quants(ii) = codebook(index(ii)+1); where ii is an integer between 1 and length(sig).  distor estimates the mean square distortion of this quantization data set.  2) out = compand(in,Mu,v,'mu/compressor') implements a µ-law compressor for the input vector in. Mu specifies µ, and v is the input signal's maximum magnitude. out has the same dimensions and maximum magnitude as in.  3)  out = compand(in,Mu,v,'mu/expander') implements a µ-law expander for the input vector in. Mu specifies µ and v is the input signal's maximum magnitude. out has the same dimensions and maximum magnitude as in similarly the functions  4) out = compand(in,A,v,'A/compressor')  and  5) out = compand(in,A,v,'A/expander')  are used to implement A law compressor and expander. |
| Procedure: | 1. Read Speech signal  2. Quantize the signal .Measure the MSE for the quantizes signal and the original signal.  3. Apply µ law to speech signal and quantize the companded signal with the same quantizer as in step 2.  4. Calculate the MSE between the original signal and the reconstructed signal after companding and quantization.  5. Comapre the results from step 2 and 4. |
| Results and Conclusion |  |