

A Brief Review on LPC and VELPC techniques for Speech Compression

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Abstract: *In this paper, we have presented a brief review of the most effective and popular technique for speech compression i.e. LPC (Linear Predictive Coding) technique and its modified version i.e. VELPC (Voice Excited Linear Predictive Coding) technique. LPC is one of the most powerful speech coding techniques and it is used widely for encoding speech signal at a low bit rate since it provides extremely accurate estimates of speech signal parameters. Though, it is a lossy technique but then also the output is easily understandable. Another method based on LPC technique which is its modified version is VELPC. VELPC eliminates the drawback of LPC technique. VELPC avoids the imprecise detection of the pitch parameter and voiced/unvoiced decision flag rather it generates an innovation signal instead.*

Keywords: Linear Prediction Coding (LPC), Voice Excited Linear Prediction Coding (VELPC), Discrete Cosine Transform (DCT), LP parameters

1. Introduction

Speech is considered as the most important factor for human communication. Speech is created at the vocal tract through vibration of vocal cords and produced at the speaker's mouth. The compression of speech is nothing but reducing its bit rate in the encoding system. Compressing the speech signal allows more and more users to share same limited allocated bandwidth than otherwise possible. Moreover, longer data can be stored easily as in answering machines.

Many types of techniques are available for speech compression. One of the most effective and popular encoding technique for low-bit rate transmission is LPC. LPC encoder estimates current sample of the speech signal using a linear combination of the past sample values. LPC is a lossy compression technique and the synthesized speech signal at the output is distorted to an great extent due to reduced bit-rate. LPC of the prediction order of 10 is usually used.

One of the modified version of LPC technique i.e. VELPC follows same procedure as LPC technique but pitch parameter and voiced/unvoiced parameter are not transmitted rather an innovation signal which is nothing but low pass filtered version of input signal is transmitted. So, VELPC results in much better synthesized signal but with little increased bit rate than LPC.

LPC based VELPC coding employs calculation of LP parameters along with generation of innovation signal. For compression of innovation signal, DCT (Discrete Cosine Transform) can be employed. DCT is used for achieving high compression rate. Since, DCT concentrates most of the energy of the signal in first few coefficients therefore signal can be compressed using only first few coefficients which contains maximum energy. DCT technique can also be used for image compression as well as video compression since it compresses efficiently.

2. Problem Statement

In LPC vocoder, the major drawback is pitch period estimation. When suddenly a peak arrives in the signal and the previous sample is smaller in magnitude and we know that in LPC we are predicting present sample based on the past sample then it will lead to large prediction error. Whenever signal changes abruptly then prediction error will be more. So, a good pitch estimation is required in order to have a good and proper synthesis of the signal. So, this alternate method which avoids pitch period estimation and utilizes voice signal itself has led to Voice Excited Linear Predictive Coding where a much better quality signal compression is achieved.

3. Methodology

LPC and VELPC, both the models are based on slow variation of vocal tract parameters. We know that speech signals are not exactly stationary rather quasi-stationary i.e. changing within very short interval in the order of 10ms-20ms. So, short speech analysis is done in both LPC and VELPC techniques. Therefore, both these techniques are based on human speech production model. In human speech production model, air is generated from lungs and travels through vocal tract. When we utter something vocal cord vibrates and the rate at which vocal cord vibrates indicates the pitch of the sound. At vocal tract, short-time speech analysis is done. Hence, vocal tract model is modeled as LPC filter model. For unvoiced sound vocal cords do not vibrate and remains constantly opened and for that pitch period is zero. The range of audio signal frequency lies between 20 Hz- 20 kHz.

LPC models the process of speech production model. LPC models this process as a linear combination of the past samples. LPC was first proposed for encoding human speech signal by the United States Department of Defence in federal standard 1015. Some applications of LPC and VELPC

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techniques are answering machines, voice mail systems, multimedia applications, text-to-speech synthesis etc.

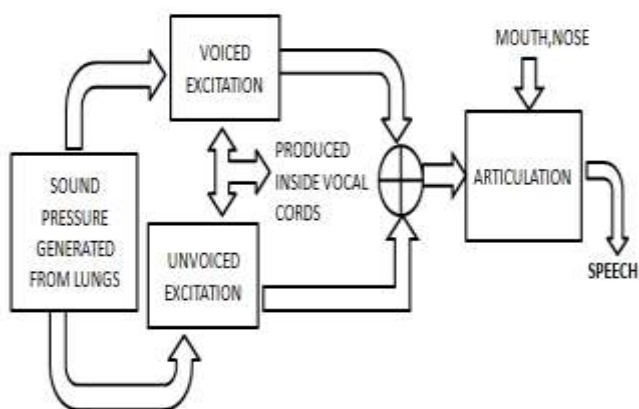


Figure 1: Human speech production model

The major differences between LPC and VELPC techniques based on the study are as discussed below. Bit-rate wise LPC is efficient but performance wise VELPC is better. Pitch period estimation is required in LPC but it is not required in VELPC. Voicing decision is done in LPC but not in VELPC. We do not need any separate impulse generator in VELPC rather the speech waveform itself is deciding the excitation signal.

The basic algorithm for LPC involves analysis and synthesis parts. The methodology required for implementing both the techniques are mentioned below. The input analog signal is first synthesized. Then the parameters of the synthesizer are encoded and then transmitted. We can say that error signal is transmitted in spite of the original signal. At transmitter, first of all analog to digital conversion takes place in both the techniques i.e. LPC and VELPC.

In LPC technique, for each frame pitch period estimation is done along with the voicing decision flag. Then, LP coefficient analysis is performed in order to obtain the inverse model of the speech spectrum. In addition to it, Gain parameter is also computed representing some function of the energy. After that, an encoding procedure is applied for transferring parameters with the goal of minimized degradation. At receiver, the transmitted parameters are decoded and by using LPC synthesis filter digital samples of speech signal is reconstructed. These samples are then passed through a digital to analog converter and a low pass filter to generate synthesized speech signal. Gain parameter is used to match the energy of synthesized speech signal to the energy of original signal.

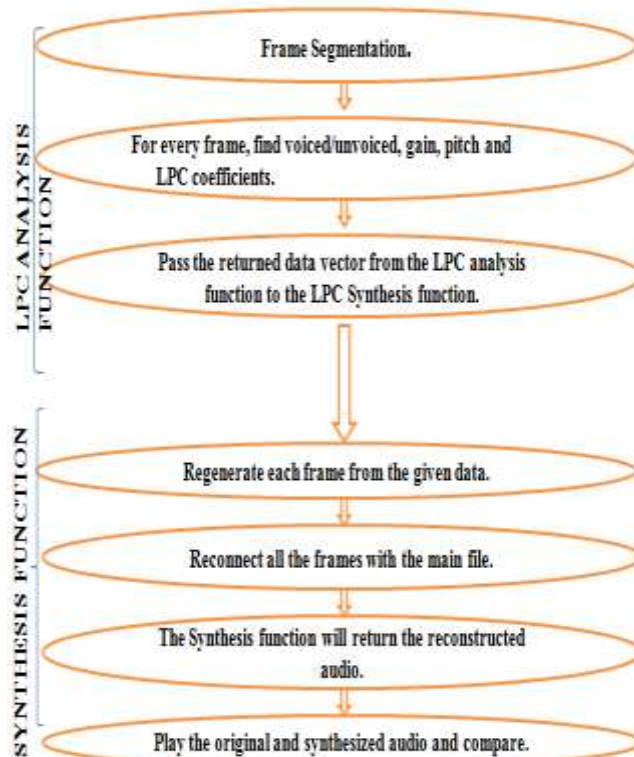


Figure 2: Flow chart for LPC technique

VELPC follows same method as LPC only with a basic difference that in VELPC, innovation signal is transmitted along with LPC parameters instead of pitch period parameter and voicing decision parameter as transmitted in case of LPC technique. This leads to improved output in terms of quality.

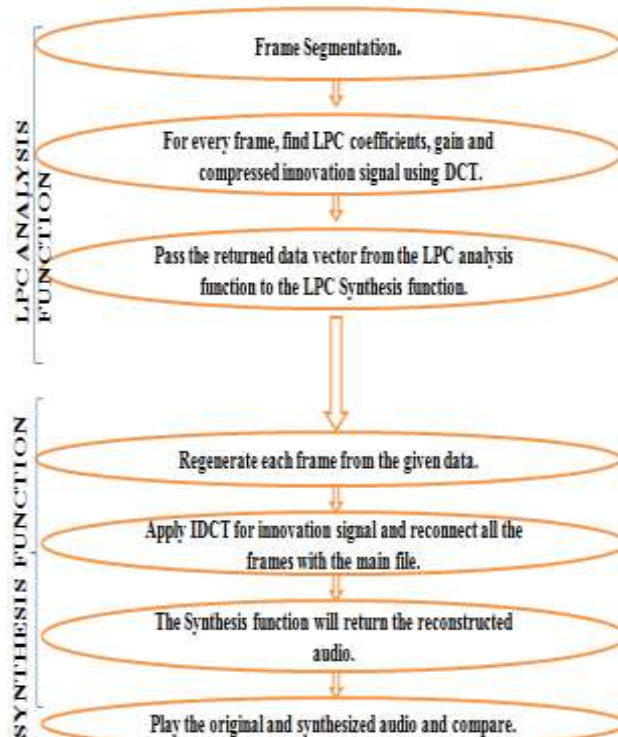


Figure 3: Flow chart of VELPC technique

4. Conclusion

This paper discusses about the speech coding techniques for low bit-rate transmission and provided the pros and cons of these methods. Although LPC proved to be an effective tool for low bit rate transmission but still the low quality output observed cannot be accepted. For this drawback VELPC stood out to be better technique than LPC however with a little increased bit-rate.

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