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Reducing and Eliminating Noise in Audio Signals

Introduction

Advances in technology have led to the proliferation of electronic devices in today's world. When coupled with the ubiquity of the internet, the pure quantity of data that can be obtained from the various sensors on these devices is incomparable to the past. As a result, there is a need to process and analyze the data quickly and efficiently. In the case of real time processing, it is often done with the aid of signal processing algorithms that are run on dedicating Digital Signal Processors (DSPs). In addition to reviewing some of the DSPs currently on the market, this paper will attempt to explore some of the options available to reduce the noise present in audio signals and their applications.

Applications in the Analysis of Microphone Signals

Since microphones often operate in non-ideal environments, background noise from the environment often creeps into the signal. As such one of the primary concerns is increasing the signal to noise ratio (SNR) of the signal of interest, namely speech. In order to do so, most systems attempt to approximate the noise spectrum in order to obtain a time invariant model of the system. This model is then used to remove the noise from the signal boosting SNR [1]. With the aid of current technological advances, a reduction of up to 18 dB is achievable [2]. However, current technology is also able to enhance the speech signal further by estimating the pitch frequency of the signal among other things. The approach can also be extended to remove the echoes caused by the microphone and speaker being in proximity to each other. Reducing these room reverberations and echoes is a subject of active study, but many systems use deconvolution filters to estimate the room impulse response from the signal. These approaches have the ability to reduce echoes by approximately 30 dB on average [2]. This further boosts the SNR and increases the sound quality.

The difficulty occurs in the fact that much of this processing needs to be done in real time to allow for ease of communication. As a result, multiple commercial companies, namely Vocal and Limes Audio have begun to fill this niche by providing custom solutions to tackle these problems. These firms offer complete solutions to these problems from acoustic echo cancellation to noise reduction with the aid of adaptive echo cancellation and non-linear processing [3]. The software options offered by these companies are compatible with most of the common DSPs available on the market including the Ti C6xx

series and the Blackfin from Analog Devices [2], [3]. In addition, a wide variety of operating systems including Linux, Windows, and Android are supported.

Digital Signal Processors

In order to cope with the demand for faster processing, multiple firms have come out with dedicated DSPs capable of processing large volumes of data in a rapid manner. Most of the DSPs in the market are optimized to handle instructions like Multiply-Accumulates (MACs) that occur frequently in digital signal processing applications [4]. In addition, some of them like the Ti C6xx series of DSPs take advantage of their Very Large Instruction Word (VLIW) architecture to implement instruction-level parallelism to achieve performance gains [5]. By running multiple execution units in parallel, multiple instructions can be executed in a single clock cycle. Much of this parallelism is focused on improving loop performance since applications run on DSPs typically spend large amounts of time executing loops. By leveraging upon a software pipelined loop, loop performance and hence DSP processing performance can be boosted further [6]. For instance, the TI C66x DSP ISA is capable of 32 MACs per cycle [7]. In addition to this, most DSP vendors also provide common software modules such as the DTS Enhance from Analog Devices to clients [8].

By taking advantage of all these optimizations, cutting edge DSPs currently on the market can perform approximately 4800-6400 million instructions per second (MIPS) at a clock rate in the range of a 600-800 MHz. However, these processors are correspondingly more expensive (340 dollars for the TMS320C6678ACYP25) [9] and typically have higher power consumption. On the lower end of the scale, the Ti C55x series of chips are more affordable with the TMDX5535eZdsp development kit for the Ti C533x family costs 99 dollars and comes with a complete set of hardware and software applications [10]. This is particularly useful for audio applications since the audio processing applications typically do not require very large amounts of computation power unlike video processing.

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