ADVANCEMENTS IN SIGNAL PROCESSING TECHNIQUES FOR COMMUNICATION SYSTEMS

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ABSTRACT

A fundamental necessity for being able to provide high data rates is that the physical channel between transmitter and receiver is efficiently utilized. Signal processing algorithms are integral part of any wireless mobile communication systems that makes this possible. Future systems should support a substantially wider and enhanced range of services and thus would require even higher data rates compared to current system in order to deliver these services. The simulation results clearly demonstrate the promise of using these different signal processing algorithms for improving the performance of wireless mobile communication systems. These techniques are capable of achieving high capacity gains at the expense of implementation complexity. Meanwhile, the system designs need to be concerned with propagation features of wireless environments. This special issue brings together some of the latest progress in new signal processing techniques for 5G networks. Under analysis was pro-posed a design process for the low Earth orbit nano-satellite communication system. Two classes of time-frequency analysis techniques are chosen for this study. Algorithms for both these techniques are developed and implemented on non-stationary signals for spectrum analysis.

Keywords: *Signal processing, time-frequency, communication system, wireless mobile communication systems, Future systems.*

INTRODUCTION

With the continuous expansion of mobile communication networks and the increasing demand for various services, people have increasingly high requirements for data transmission quality. In particular, on the communication link, signal processing often has the defects of large data, small information capacity, and time extension, leading to low system operation efficiency. Therefore, improving the efficiency of signal transmission has become a very urgent and difficult problem. Signal processing has always been the focus of attention. Provide an overview of the latest deep learning technology used in audio signal processing, which covers prominent application fields, including audio recognition, synthesis, and conversion, and identified the key issues and future trends in the application of deep learning in audio signal processing. Review the latest progress of photonic RF signal processors based on the micro-comb, including real-time delay, a reconfigurable filter, a Hilbert transformer, a differentiator, and a channeler, and discussed the powerful potential of the function and integration of optical micro-comb in RF photonics applications. Ortega et al. outlined the core idea of graph signal processing and its connection with traditional digital signal processing (DSP) and analyzed the application of signal processing in sensor network data processing and analysis, biological data, and image processing and machine learning (ML), which provided a new idea for signal processing based on image information in the future. Analyze several key signal processing algorithms in deep learning, including convolutional neural network and adaptive filtering, and proposed a new, improved method combined with the idea of local optimization, which reduced the computational complexity and improved the training efficiency under the premise of ensuring a high recognition rate.

LITERATURE REVIEW

Li Liu (2023) Mobile phones are the most commonly used electronic devices in people's daily life. The image, voice, and other information in these devices need to be processed through signal transmission. The role of signal processing is to process the acquired information in a certain way to get the final result. In order to ensure that the whole processing program can work normally, it is necessary to implement good control to achieve the desired effect. However, with the continuous progress and development of science and technology, its requirements are becoming increasingly strict. The traditional signal processing method is unreliable, has poor real time, and has error-prone characteristics, which can no longer meet the accuracy requirements of current information acquisition equipment.

Weizhi Sun (2022) With the popularization of the Internet and the rapid development of new technologies such as artificial intelligence, cloud computing, and the Internet of Things(ITS), the explosive growth of data traffic puts forward higher requirements for transmission performance. In order to meet the ever-increasing demand for capacity and cope with the ensuing crisis, the application of digital signal processing technology in the communications field is imperative. With the development of high-speed integrated circuits and digital signal processing algorithms and other technologies, high-speed digital signal processing has become increasingly mature, and ITS has become one of the global research hotspots. The country is also strategically advancing the research on ITS.

Nickolay Zosimovych (2021) This study proposes a communication system for nanosatellite Earth observation preliminary design technique as useful tools for managing and improving various aspects of regional and national resources. In proposed paper have been formulated and solved next goals: re-viewed Earth observation systems and studied their design parameters, analyzed the on-board antennas design background and provided analytical estimations, such as design a passband quadrature phase shift keying transmitter and receiver in Simulink, was obtained a bit error rate curves by using a Sim-ulink/MathWorks, generated an offset quadrature phase shift keying waveform and investigated their characteristics, observed and analyzed the diagrams, constellation, and the signal trajectories of quadrature phase shift keying ac-cording contemporary design concept.

Ma Xuejiao (2020) With the continuous development of modern information technology and the continuous improvement of people's living standards, electronic information technology has been widely used in people's lives. People's lives are inseparable from it. With its continuous development, its application range is getting wider and wider. This article first gives a brief overview of digital signal processing technology, analyzes the advantages and disadvantages of digital signal processing technology in the communication field, and the specific applications of speech compression coding and software radio in communication are analyzed in order to better promote the application of digital signal processing technology in the communication field.

Muhammad Altaf (2018) The distinguished features of the smart grid are monitoring capability with data integration, advanced analysis to support system control, enhanced power security and effective communication to meet the power demand. Efficient energy consumption and minimum costs are also included in the prodigious features of smart grid. The smart grid implementation requires intelligent interaction between the power generating and consuming devices that can be achieved by installing devices capable of processing data and communicating it to various parts of the grid. The efficiency of these devices is greatly dependent on the selection and implementation of the advance digital signal processing techniques.

Signal processing

Signal processing is an electrical engineering subfield that focuses on analyzing, modifying and synthesizing signals, such as sound, images, potential fields, seismic signals, altimetry processing, and scientific measurements. Signal processing techniques are used to optimize transmissions, digital storage efficiency, correcting distorted signals, subjective video quality, and to also detect or pinpoint components of interest in a measured signal.

Signal Processing Works

Signal processing involves the representation, manipulation, and analysis of analog and digital signals. The steps involved can vary depending on the specific application and the goals of the signal processing system.

Here is a general outline of the signal processing process:

Signal acquisition: The first step in signal processing is to acquire the input signal. This may involve using sensors to measure physical quantities such as temperature, pressure, or acceleration, or it may involve capturing audio, video, or other types of data.

Signal conversion: If the input signal is in an analog format, it may need to be converted into a digital format using an analog-to-digital converter (ADC). This allows the signal to be processed using digital techniques, such as mathematical operations and algorithms.

Signal representation: The input signal is then represented in a suitable form for processing. This may involve representing the signal as a discrete sequence of samples or as a continuous function.

Signal manipulation: The input signal is then manipulated using various techniques such as filtering, noise reduction, compression, and feature extraction. These techniques can be implemented using algorithms and mathematical operations.

Signal analysis: The manipulated signal is then analyzed to extract useful information or to make decisions.

Signal synthesis: The output of the signal processing system may be a synthesized signal, which is generated based on the processed input signal and any additional information or constraints.

Signal output: The final step in signal processing is to output the resulting signal. This may involve converting the signal back to an analog format using a digital-to-analog converter (DAC) or displaying the signal on a screen or speaker.

Signal Processing Techniques

There are many techniques used in signal processing, including:

Filtering: This involves removing unwanted frequency components from a signal. There are many types of filters, including low-pass, high-pass, band-pass, and band-stop filters.

Fourier analysis: This is a method for representing a signal as a sum of sinusoidal functions. It is used to identify the frequency components of a signal and to analyze its properties.

Noise reduction: This involves removing or reducing unwanted noise or interference from a signal. Techniques for noise reduction include filtering, averaging, and the use of noise-canceling algorithms.

Compression: This involves reducing the size of a digital signal by removing redundant or unnecessary information. Compression is often used to reduce the size of audio and video files for storage or transmission.

Modulation: This involves encoding information onto a carrier signal for transmission over a communication channel. There are many types of modulation, including amplitude, frequency, and phase modulation.

Demodulation: This is the process of extracting the original information from a modulated signal. It is the inverse of the modulation process.

Application fields

- Audio signal processing – for electrical signals representing sound, such as speech or music
- Image processing – in digital cameras, computers and various imaging systems
- Video processing – for interpreting moving pictures
- Wireless communication – waveform generations, demodulation, filtering, equalization
- Control systems
- Array processing – for processing signals from arrays of sensors
- Process control – a variety of signals are used, including the industry standard 4-20 mA current loop
- Seismology
- Financial signal processing – analyzing financial data using signal processing techniques, especially for prediction purposes.
- Feature extraction, such as image understanding and speech recognition.
- Quality improvement, such as noise reduction, image enhancement, and echo cancellation.
- Source coding including audio compression, image compression, and video compression.
- Genomic signal processing
- In geophysics, signal processing is used to amplify the signal vs the noise within time-series measurements of geophysical data. Processing is conducted within either the time domain or frequency domain, or both.

RESEARCH METHODOLOGY

Signal processing plays a key role in capturing and processing sound from the environment in order to enhance and amplify what the user uses the device. In this process, the sound is converted from analogue to digital with the least possible delay and then back to analogue and is directed to the ear. When the signal is processed, first in different areas including time, frequency, etc. are checked to perform operations such as noise cancellation or extraction of important and required features in the signal or packaging of their information. After the pre-processing operation on the signal processing operations, the trick is ready for its information to be entered into classification and detection algorithms for classification and diagnosis. As a result, any noises in the sound signals are eliminated to increase the quality of communication systems. The implementation in a FPGA should be optimized to achieve the new frequencies. One of the most usual problems working with FPGAs is the logic speed for an implemented design. For this reason, polyphase structures have been implemented The core of auditory rehabilitation technology consists of four coordinated parts: microphone, processor, receiver and power source. Theoretical analyzes and inferences in DSP are usually performed on time-discrete signal models without amplitude error (quantification error) "generated" during the abstract sampling process. Numerical methods require quantified signals, such as signals generated by an ADC. The processed result may be a frequency spectrum or a set of statistical indicators. But, it is another quantified signal that is converted to analogue by a Digital-to-Analog converter (DAC). To digitally analyze and manipulate an analogue (continuous) signal, it must be digitized by an analogue-to-digital converter (ADC). Sampling is usually done in two stages, discretization and quantification.

RESULTS

Coincidence time resolution (FWHM) has been obtained for the different time pick-off methods. Exacts results are shown in Table I.

In amplitude and charge BCFD are compared for different configurations. A synthesized frequency is represented in each graph (non-interpolated, interpolated by factor 2, and interpolated by factor 3). In the non-interpolated case, charge BCFD gives us better results for delays smaller than 3, although for greater delay values, amplitude BCFD resolution is better, achieving a minimum for k=6. When an interpolation with factors 2 or 3 is applied, the charge BCFD has better resolution for all the evaluated delays.

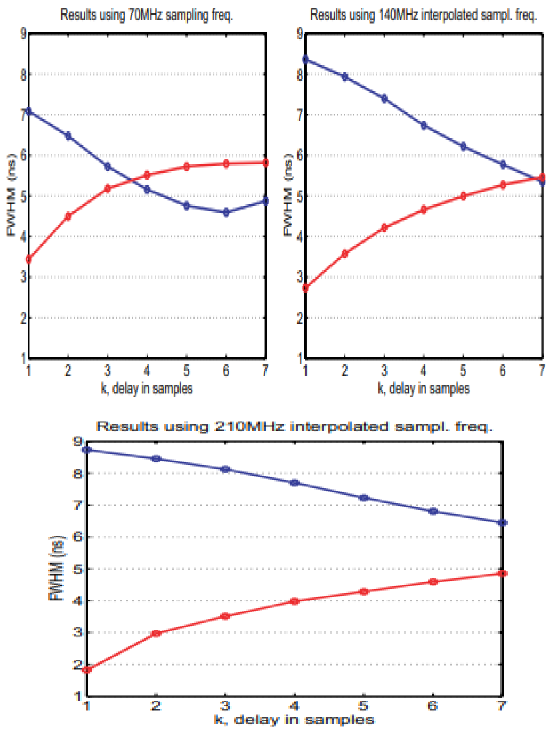
The evolution of FWHM time resolution as a function of the delay can also be observed. The Charge BCFD algorithms achieve their best results for low delays. For high delays, the results converge to a constant FWHM value. Regarding Amplitude BCFD algorithms, different behaviors have been observed. In this case, the worst results are observed with low delays. There is an optimal delay value which has the minimum FWHM time resolution. For delays greater than this value, the FWHM time resolution increases.

Table 1: Difference Time Coincidence Fwhm Results For The Evaluated Time Pick-Off Algorithms.

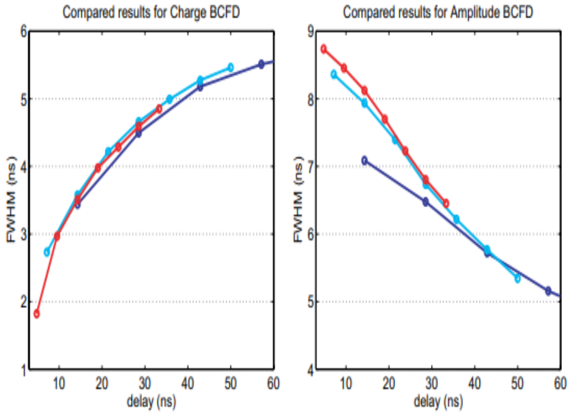
Delay in	**70MHz sampling frequency**	**140MHz interpolated sampl. freq.**	**210MHz interpolated samp. freq.**
samples, k	Charge BCFD	Charge BCFD	Charge BCFD
1	3.4380 ns	2.7316 ns	1.8203 ns
2	4.4977 ns	3.5793	2.9671 ns

		ns	
3	5.1806 ns	4.2151 ns	3.5087 ns
4	5.5103 ns	4.6625 ns	3.9796 ns
5	5.7222 ns	4.9922 ns	4.2858 ns
6	5.7929 ns	5.2748 ns	4.5919 ns
7	5.8164 ns	5.4632 ns	4.8509 ns

Best time resolution using Charge BCFD is 1.82ns FWHM. In this case, the Charge BCFD was configured with k=1 and interpolated by 3. For Amplitude BCFD, the best result that has been achieved in this work is 4.58ns FWHM, as can be observed in Graph 1.



Graph 1: Compared results between amplitude BCFD and charge BCFD for different sampling frequencies. red: using charge BCFD, blue:amplitude BCFD. a) 70MHz sampling frequency b) 140MHz interpolated sampling frequency c) 210MHz interpolated sampling frequency.



Graph 2: Comparison of time coincidence resolution results using a) Charge BCFD or b) Amplitude BCFD, with different interpolation factors: blue, non-interpolated (fs=70MHz); cyan, x2 interp. ($fs_{equivalent}$ 140MHz); red, x3 interp.($fs_{equivalent}$ =210MHz).

In this case, the Amplitude BCFD was configured with k=6 and no interpolation was applied. The method with worst results had 8.7ns FWHM. This result was achieved for Amplitude BCFD, k=1, interpolated by 3.

Difference between the best and the worst results is 6.9 ns. The coefficient k can be seen as a time shift, just multiplying k by the sampling period. In this way, all the charge or amplitude methods can be represented in the same graph as a function of this delay (Graph 2). This shows us the influence of interpolation on time resolution. It can be observed that there are points where the interpolated and non-interpolated methods are equivalent.

CONCLUSION

In the field of communication, the application of digital signal processing technology is mainly manifested in speech compression coding and software radio. With the rapid development of emerging new technologies and applications in communications, future communications networks will be a highly complex and dynamic environment. Signal processing applications include audio signal processing, audio compression, digital image processing, video compression, speech processing, speech recognition, digital telecommunications, digital instrument combinations, radar and sonar signal processing, financial signal processing, seismology and biopharmaceutical. Some important challenges in signal processing technologies that must be catered for future communications to achieve ultra-high data rate, intelligence, high energy and spectral efficiency scalability. Advancement in signal processing technologies and optimization tools will pave the way and fuel innovation for future communication systems. Although its advantages are relatively obvious and it is a development trend in the future, there are still certain shortcomings, such as signal quality and signal transmission rate. Therefore, it is necessary to continue the research on digital signal processing technology in communication in the future to ensure more convenient and reliable communication.

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