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Survey on IIR and FIR Digital Filter

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Abstract: Digital filters has developed a lot of applications on different fields. Fundamentally, Filters are used to remove the unwanted frequencies from applied signal which have both wanted and unwanted signals. Digital filters are of two types: Infinite impulse response (IIR) and finite impulse response (FIR). Infinite impulse response digital filters are recursive (feedback type) systems that involve fewer design parameters, less memory requirements, and lower computational complexity than finite impulse response digital filters. This paper represents the comparison of both IIR and FIR filters to find the better most technique for digital signal. importance.
Keywords: ***IIR, FIR, Digital Filter, DSP, FDA***

I. INTRODUCTION

Speech is the most fundamental way of communication used by human being. Speech signal is one dimensional signal and has comparatively low bandwidth of 8kHz. This is very useful in various applications with different evolving technologies. Noise is an undesirable signal. When it is mixed with speech signal, it is very difficult to deliver actual information from one place to another. To differentiate original information containing signal from unwanted noise; filtering is a basic and common method. Filters extract useful information from its input depending upon its configuration.

The basic functional need for filtering is to pass a range of frequencies while rejecting others. This need for filtering has many technical uses in the digital signal processing (DSP) areas of data communications, imaging, digital video, and voice communications. Analog filters are continuous-time systems for which both the input and output are continuous-time signals. Digital filters are discrete time systems whose input and output are discrete time signals. Digital filters are implemented using electronic digital circuits that perform the operations of delay, multiplication, and addition. Analog filters are implemented using resistors, inductors, capacitors, and, possibly, amplifiers. Digital filters can be implemented using integrated circuits so that as the per unit cost of digital filter construction is less than a comparable analog filter. Tolerances and accuracy considerations are important factors for both analog and digital signal processing. A system designer has much better control of accuracy of digital systems in terms of word length, floating point versus fixed-point arithmetic, and other similar factors. These are the major advantages of digital filters.

A. Infinite Impulse Response

Digital IIR filter is one of the most commonly used computation tools in the digital signal processing systems. Digital IIR filters are used many application such as high-speed and low-power communication transceivers, they are also used in routinely employed as accustom designed digital block [1]**.** IIR Filters are infinite response filter, they have impulse response of infinite duration. IIR filter are recursive filter in which feedback is present from output side to the input side. IIR filter response is depending upon the previous output samples, present and past input samples. Digital IIR filters are one of the most frequently used computational tool used in digital signal processing. It is used in much application such as high-speed and low-power communication transceivers systems.

B. Finite Impulse Response

In recent years, FIR digital filters has gained much popularity due to the convenience and flexibility with which it can be used. But the design of filter for removing noise and achieving exact frequency response with high stop band attenuation and low stop band and pass band ripples also become important at the same time. Various techniques that have been used in the past for this purpose have been discussed in the section II and the conclusion of the review has been given in section III, thus summarizing the whole discussion.

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TABLE I

S. No.	FIR Digital Filter	IIR Digital Filter
1	Impulse input: if x(n)= δ(n)), y(n)=h(n) is the impulse response that has finite extent.	The length of {y(n)} may be infinite!
2	Computation is the same as convolution	Stability concerns: – The magnitude of y(n) may become infinity even all x(n) are finite – coefficient values, – quantization error
3	Let {h[n}: impulse response {x(n)}: input, {y(n)}: output	Infinite impulse response (IIR) filter $y(n)=\sum_{i=1}^{P} a(i)y(n-i)+\sum_{k=0}^{Q} b(k)x(n-k)$
4	Finite impulse response (FIR) filter: $y(n)=\sum_{j=0}^{J-1} h(j)x(n-j)$	$\frac{Y(z)}{X(z)}=\frac{\sum_{m=0}^{Q} b(m)z^{-m}}{1+\sum_{k=1}^{P} a(k)z^{-k}}=\frac{B(z)V(z)}{A(z)V(z)}$
5	FIR filter can be implemented using direct form or fast convolution methods like FFT hence STABLE.	IIR filters are often factored into products (cascade realization) or sum (parallel realization) of 1st order or 2nd order sections due to numerical concerns(Manual Calculation only possible)
6	Realized by Non-Recursive methods.	Realized by Recursive(Feedback) methods
7	They have LINEAR PHASE.	They don't have linear phase & hence are used at places where phase distortion is tolerable.
8	Less susceptible to Noise.	More susceptible to Noise.
9	Storage Requirements & Arithmetic operation is more here.	Storage Requirements & Arithmetic operation is less.
10	Greater Flexibility to control the shape of their Magnitude response & Realization Efficiency.	Less Flexibility to control the shape of their Magnitude response.

Whenever in general terms it is discussed about digital filter coefficient, it is presumed that it is being discussed about ideal one i.e. infinite precision. But, when it is implemented in special-purpose digital hardware or as a computer algorithm, attention must be paid to the effects of using finite register length (i.e. finite precision) to represent all relevant filter parameters. Here, quantization noise of digital filter is taken into consideration that is quite different from the quantization error due to Analog-to-Digital conversion. This noise is affected by the arithmetic used in the filter algorithm, the type of quantization used to reduce the word length to desired size, filter structure and arrangement of second order sections (SOSs).

II. ADVANTAGE OF IIR FILTER OVER FIR FILTER

As we have gone through various techniques for designing purpose of both the filters IIR & FIR. So select which of the filter will be suitable whether IIR or FIR and which procedure should be select to design appropriate filter for given application are important. However, it is possible to attempt some meaningful comparisons between these two filters. The Advantage of IIR filter over the FIR filter are given below .

A. IIR can attain a given filtering characteristic via less memory and calculations than a similar FIR filter.
B. The less number of side lobes are required in the stop-band of IIR filter.
C. IIR requires low order than the FIR for designing the same filter.
D. It can get all the preferred specification by low computational cost.

III. CONCLUSION

This paper surveys IIR And FIR Digital Filter techniques. Each technique has its own advantages, and disadvantages. From

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literature, we found that most of the recent IIR filtering based methods employ to obtain an improved signal with minimum noise. It is found that IIR filter has less computation complexity and cost effective than FIR filter. The literature review findings have solidified idea of using the optimization filter for the quality improvement and the signal size reduction. In this paper, comparative table shows that IIR filter is best choice for filter the signal.

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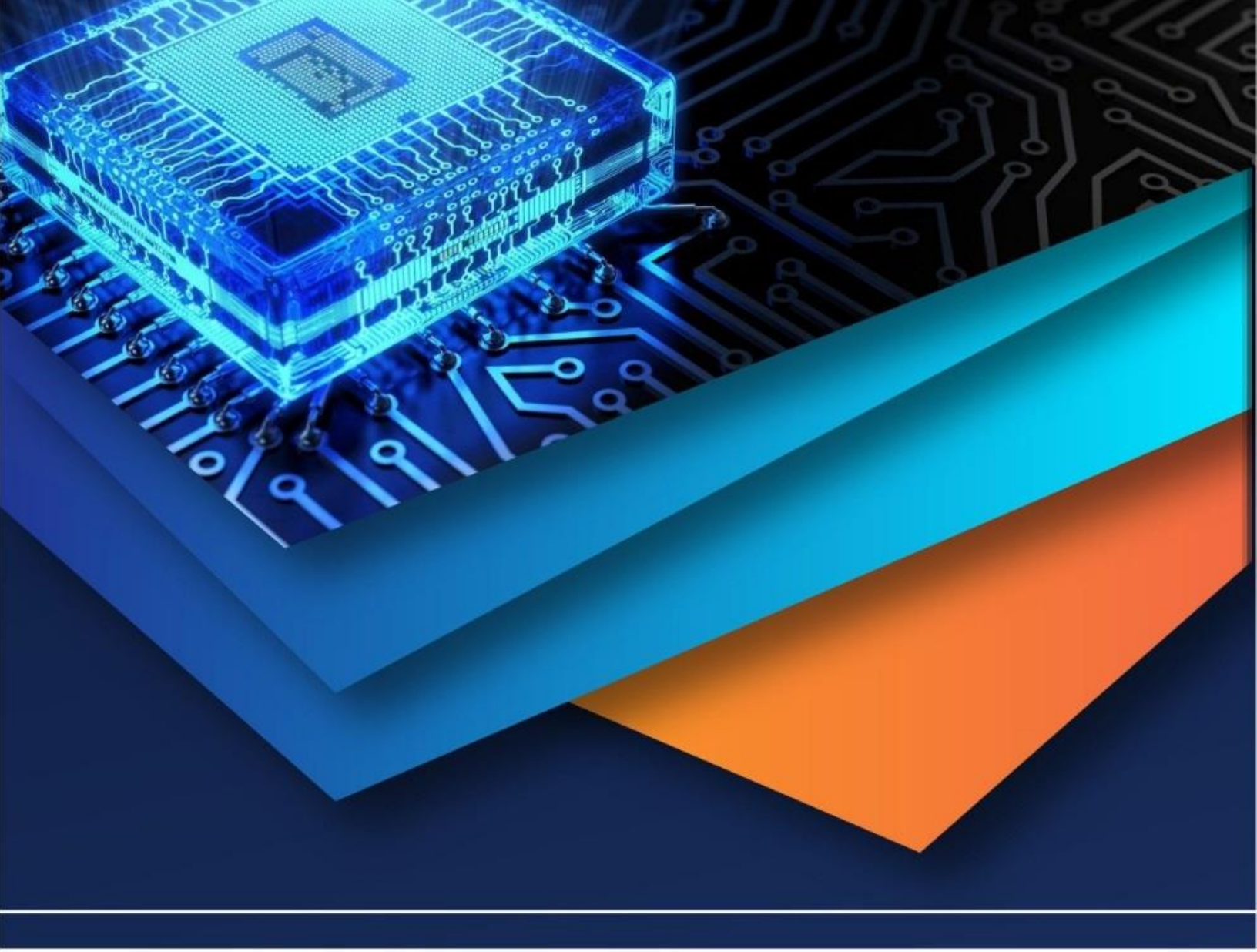

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