Review on Digital FIR filter design

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Abstract

Filter is an essential part in digital signal processing (DSP). Two dimensional (2D) digital filters have found wide application in different areas like image processing, seismic processing, and nuclear test detection. Sparsity has been a great issue in design of FIR filter. Designers pay attention on designing a filter with majority of coefficient being zero. The proposed paper discusses various techniques used earlier for designing a sparse FIR filter. This paper also presents the comparative study of several filter designing methods used by researchers for this work.
Keywords: Seismic processing, Scarcity.

1. Introduction

Filter removes the harmful constituents from the signal. The unwanted components present in the signal is noise .FIR filter have a variety of applications in signal processing, communication field, image area and medical field. Traditional design strategies aim to reduce the implementation complexity of an FIR filter. This includes designing of FIR filter with power of two coefficients or making use of special structures such as frequency response masking technique with the advancements in sparse representation of signals.

The classical techniques for designing 2D filters are the generalized extension of 1D design techniques these include windowing, frequency sampling, chebysev approximation, McClellan transformation and least squares.

The objective of sparse filter design is to reduce the implementation complexity as the number of non-zero coefficients is reduced. In general to evaluate the scarcity of filter coefficients one can adopt l0 norm of a coefficient vector which counts the number of nonzero coefficients. The various techniques include sparse FIR filter design using linear programming, weighted least-square algorithm (WLS), iterative shrinkage/thresh holding (IST), iterative-reweighted-least squares (IRLS) and genetic algorithm. In this paper merits and demerits of different approaches used to design sparse FIR filter.

2. Literature Review

[1995 Sriranganathan]
This paper has demonstrated the power and robustness of Generic Search Algorithm(GSA)[1].Here circularly symmetric and diamond shaped low –pass linear –phase FIR filters designed. A minmax error criterion is adopted which leads to a minimization of the weighted ripple extreme in both pass and stop bands. The results presented are compared with those obtained using simulated annealing linear programming and simple rounding of an optimum. Filter designed using GSA are found to better than those designed using other methods.

[1999 Compeanu]
This paper proposes a very powerful technique of constrained least square minimization to determine the optimal value of coefficients of McClellan transformation used to map very effectively 1-D filter prototype in 2-D FIR filters.[2] And while designing arbitrary shape paper includes circularly symmetric and diamond-shaped filters, elliptically symmetric and 2-D fan filters.

[2000 Lu]

In this paper a review on an optimal method is given to determine the coefficients if the McClellan transformation in least square error sense along with designing of 2-D finite impulse response filter [3].The proposed method can be utilized to design 2-D fan filters with arbitrary inclination, elliptically symmetric filters, elliptically symmetric filters with arbitrary orientation, circular filters, and diamond-shaped filters.

[2003 Mastorakis]

In this study,the design of 2-D recursive filters is attempted by using an appropriate evolutionary computational scheme and using genetic algorithm(GAS)[4]. The design approaches for 2-D filters can be broadly classified into two categories that is those based on appropriate transformation of 1-D filters and those based on appropriate optimization techniques.

[2004 Tzeng]

In this paper the symmetric properties of 2-D sequences and their application for designing linear-phase 2-D FIR digital filters have been presented [5]. Here the start is from the discussion of the symmetric properties of 2-D sequences to disclose their applications for designing linear-phase 2-D FIR digital filters by the proposed genetic algorithm (GA) approach, which has been successfully used to design 2D FIR filters using McClellan transformation, FIR Hilbert transformers and differentiator, higher-order digital differentiators the definition of quadrant AL-plane, half-plane, and full-plane filters are also described.

[2006 Elad]

This work has presented a simple method for image DE noising[6].The several research directions that are considered such as using several dictionaries and switching between them by content, optimizing the parameters, replacing the OMP by a better pursuit technique, and more. The approach taken is based on sparse and redundant representation over trained. By using K-SVD algorithm a dictionary was obtained which describes the image content effectively.

[2007 Gustafsson]

In this work we consider the design of sparse FIR filters ,i.e. filters with few non-zero multiplications [7] .The considered filters have half-band like properties, but with slightly relaxed specifications compared with actual half-band filters. We propose a filter design technique where the number of non-zero filter coefficients is minimized.

[2007 Lai]

This paper aims to find the smallest length filter that satisfies the specified magnitude error constraint .The paper only provide examples of elliptical high pass, rectangular band–pass and diamond-shaped low-pass filters ,the procedure can also be applied to others of 2D FIR filters such as low-pass ,high- pass, band pass and band-stop filters of the elliptic, rectangular and diamond-shaped types. They referred Q-search in order to emphasize the importance of the logarithmic MSNE in the search process.

[2008 Yeh]

In this paper an effective genetic algorithm(GA) approach for evaluating the best coefficients in the McClellan transformation and the corresponding cut-off frequency of the 1-D filter was presented[9].A generalized McClellan transformation is presented. This work proposes approaches for designing 2-D fan filters of arbitrary inclination, elliptical filter of arbitrary orientation, circular filters, and diamond-shaped filters. The double transformation approach is proposed to design 2-D FIR filters whose transition band is sufficiently narrow and full-plane complex.

[2011 Elkarami]

In this paper, GA combining with SVD is used to design 2-D FIR filters. [10].GA is used as an optimization technique to design I-D filters. The filter is encoded into CSD system. This design requires less multiplier than a direct 2-D implementation .Here GA is used to design I-D digital filters.

[2011 Rusu]

By combining two of the most popular approaches in the field of sparse representation author have developed a new efficient method called IRL1G that can used to design sparse 1-D and 2-D FIR filters [11]. In the first stage, reweighted l1 minimization (IRL1) is used to induce a relatively large number of zero coefficients and then, in the second stage, greedy iteration are used to cut down extra coefficients one by one. In this paper amplitude responses of the sparse 2-d FIE diamond shaped low pass filters generated.

[2012 Jiang]

A novel algorithm is proposed for sparse FIR filter design [12].An iterative procedure is developed to find a potential scarcity pattern. The proposed algorithm can yield comparable or better solutions than other existing design algorithms. Besides sparse FIR filter design discussed in this paper.

[2012 Kuang]

This paper was focused on a new method to design of nearly optimum four fold symmetry [13]. 2-D FIR filters is presented in this paper. Based on the uniform frequency sampling and DEPSO algorithm, acceptable 2-D FIE filters can be produced. Paper represents a method to refine the conventional frequency sampling method. And the generated low pass filters can be superior to the median filter in DE noising Gaussian noise corrupted images.

[2012 Manuel]

This paper has opted a new approach for the designing of 2-D multiplier less sharp FIR filter [14].And also includes a novel population-based optimization algorithm called Gravitational Search Algorithm (GSA) for the design and optimization of FRM FIR digital filter which is based on Newtonian law of gravity and law of motion.

[2013 Wei]

This paper considers three problems in sparse filter design [15],the first involving a weighted least-squares constraint on the frequency response, the second constraint on mean squared error in estimation, and the third a constraint on signal to-noise ratio in detection. The three problems are unified under a single frame work based on scarcity maximization under a quadratic performance constraint.

[2014 Chandra]

Through this paper a novel design strategy of multiplier-less two dimensional low passes DE noising filter with the aid of Differential Evolution Algorithm was proposed [16].Proposed algorithm has been formulated for a fixed setting of the control parameters of delike waiting factor, cross –over probability.

[2014 Ye]

In this paper [17], a bit level multiplier less FIR filter optimization technique is proposed. By incorporating the sparse filter with proper sparsity control scheme, for the first time, the bit-level efficient optimization of multiplier less FIR filter becomes possible.

[2015 Jiang]

In this paper [18], to novel algorithm are developed to design sparse linear-phase (LP) FIR filters. Compare to traditional design methods they can jointly optimize coefficient scarcity an order of an LP FIR filter, so as to achieve a balance between filtering performance and implementation efficiency.

[2015 Wang]

A novel separable 2-D FIR design in proposed in this paper [19].The proposed design deals with a sub matrix of the prototype 2-D FIR filter coefficient matrix, which contains all the information of the filter

coefficient matrix. And, its basic idea is to try to utilize some column vectors of the sub matrix itself to decompose this sub matrix. There are zero-valued AND/OR one-valued coefficients in the proposed filter in this filter implementation, these zero- valued coefficients do not require multipliers or adders.

[2016 Ye]
A greedy algorithm for the design of sparse linear-phase finite impulse response filters where in the coefficients successively fixed to zero individually is proposed [20].To meet the filter specification, the coefficient for which the middle value of its feasible range is closest to zero is selected to be set to zero, whereas all the other unfixed coefficients are free to change.

[2017 Kockanat]
In this paper [21], met heuristic algorithms where applied to optimize the 2-D FIR filter coefficients matrix for medical image De noising by using the proposed noise elimination approach. The considerable advantage of met heuristic algorithms is that they don't need to be adapted in detail for each optimization problem.

3. Conclusion & Future scope.

Here 2 dimensional FIR filter has been designed. Some of future developments include the contents that we can design this for any particular application we can specially design this, using some recent technique we can design according to that recent technique and low power processor can be designed.

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