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FIR Filter Design with Speed Multiplier

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Abstract —*The speed multiplication operation has impact in Digital Signal Processor (DSPs) and as well as general processor. Finite Impulse Response (FIR) channel with higher pace is of extraordinary significance. FIR channel is additionally called convolution filter since convolution is the central idea of outlining FIR filter. Vedic Mathematics depends on 16 sutras. One of the sutra is Urdhava Tiryagbhyam which conveys a distinct in the real procedure of multiplication itself. In this paper, we proposed a speed multiplication operation in view of Urdhava Tiryagbhyam sutra to outline FIR filter utilizing window. This calculation is actualized in MATLAB and performed in GUI. Further the execution time taken by FIR filter processor is looked at by Urdhava of Vedic strategy and inbuilt MATLAB function. In the outcomes, it can be seen that FIR filter based on Urdhava Tiryagbhyam sutra reduces the execution time when compared with inbuilt function of MATLAB.*

Index Terms— *DSP, FIR filter using window, Urdhava Tiryagbhyam sutra, Vedic multiplier.*

I. INTRODUCTION

Fast multiplier is a standout amongst the most vital segments in planning Digital Signal Processors (DSPs) [1, 2]. Computerized Signal Processing (DSP) operations [3], for example, convolution, connection, Fast Fourier Transforms (FFTs) and so forth make utilization of multipliers. Computational pace and execution time are the two elements that choose the productivity of duplication calculation [4].

In DSP, separating is a typical term that is connected to different applications. Advanced video require computerized channels to lessen clamor because of coding and transmission through an uproarious channel [5]. When all is said in done, any operation performed to extricate needed data from an advanced sign is termed as separating. The execution time and speed of sifting by FIR channel processor is dictated by the velocity of

its multiplier. Numerous DSP applications require convolution operation for separating of signs. Accordingly direct convolution is the crucial idea for executing the FIR channel. The scientific recipe to discover straight.

convolution is same as Urdhava Tiryagbhyam sutra of Vedic science. In this paper, an examination is set aside a few minutes taken by

FIR channel processor utilizing Vedic technique and traditional strategy for MATLAB. The paper is sorted out into VII parts. Part II spreads light over Vedic arithmetic; III clarifies Urdhava Tiryagbhyam;

II. VEDIC MATHEMATICS

Vedic arithmetic [6] is an antiquated science that has a novel arrangement of calculation in light of basic tenet and fundamental standards with which scientific issue can be comprehended. It manages numerous current numerical terms including number juggling, trigonometry, geometry (plane, co-ordinate), quadratic comparisons, factorization and even math. The excellence of Vedic science lies in the way that it decreases the intricate looking figurings in routine arithmetic to an exceptionally straightforward one. This is so on the grounds that the Vedic formulae are guaranteed to be founded on the regular standards and sutra on which the human personality works. This is an extremely fascinating field and introduces some viable calculations which can be connected to different branches of building, for example, figuring and computerized signal handling.

His Holiness Jagadguru Shankaracharya Bharati Krishna Teerthaji Maharaja (1884-1960) included this work together and gave its scientific clarification while examining it for different applications. Swami-ji built 16 sutras (formulae) and 16 Upa sutras (sub formulae) after broad exploration in Atharva Veda. These formulae are not to be found in present book of Atharva Veda in light of the fact that these formulae were built by Swami-ji himself. Vedic science is a scientific miracle as well as it is consistent. That is the reason Vedic Mathematics has such an extent of distinction which can't be objected. Because of these amazing trademark, Vedic Mathematics has effectively crossed the limits of India and has turned into a main exploration subject in abroad. Vedic Mathematics manages a few basic and in addition

complex numerical operations. Particularly, techniques for fundamental number juggling are amazingly straightforward and intense [6, 7].

"Vedic" is a Sanskrit word got from "Veda" which implies the accumulation of all information. Veda is a blessing from antiquated sages of India to this world. From the old times Vedas were gone from past era to cutting edge orally instead of composed. Vedic science is for the most part in view of 16 Sutras (or axioms) managing different branches of math like number-crunching, algebra, geometry etc. These Sutra's meanings with few words are enlisted below alphabetically:

1. (Anurupye) Shunyamanyat – If one is in ratio, the other is zero.
2. Chalana-Kalanabyham – Differences and Similarities.
3. Ekadhikina Purvena – By one more than the previous one.
4. Ekanyunena Purvena – By one less than the previous one.
5. Gunakasamuchyah – The factors of the sum is equal to the sum of the factors.
6. Gunitasamuchyah – The product of the sum is equal to the sum of the product.
7. Nikhilam Navatashcaramam Dashatah – All from 9 and last from 10.
8. Parvarya yojayet – Transpose and adjust.
9. Puranapuranabhyam – By the completion or no completion.
10. Sankalana- vyavakalanabhyam – By addition and by subtraction.
11. Shesanyankena Charamena – The remainders by the last digit.
12. Shunyam Saamyasamuccaye – When the sum is the same that sum is zero
13. Sopaantyadvayamantyam – The ultimate and twice the penultimate.
14. Urdhava-tiryagbhyam – Vertically and crosswise.
15. Vyashtisamanstih – Part and Whole.
16. Yaavadunam – Whatever the extent of its deficiency.

The Sub Sutras are

1. Anurupyena
2. Shishyate Sheshsamjnah
3. Adyamadye Nantyamantyena
4. Kevalaih Saptakam Gunyat
5. Vestanam
6. Yavadunam Tavadunam
7. Yavadunam Tavadunikutya Varganka ch Yojayet
8. Antyayordhshakepi
9. Antyatoreva
10. Samucchayagunitah
11. Lopanasthapanabhyam
12. Vilokanam
13. Gunitasamucchyah Samucchayagunitah

III. URDHAVA-TIRYAGBHYAM

Urdhava Tiryagbhyam Sutra is a general increase equation appropriate to all instances of augmentation. Urdhava Tiryagbhyam is Sanskrit word which signifies "Vertically and across" [8, 9]. The increase depends on a calculation called Urdhava Tiryagbhyam (Vertical and Crosswise) of old Indian Vedic Mathematics. The Urdhava Tiryagbhyam is dependably work for much number of arrangement and gives odd number of groupings. Urdhava Tiryagbhyam sutra is otherwise called exhibit duplication procedure. It depends on a novel idea through which the era of every single incomplete item should be possible with the simultaneous expansion of these fractional items. The parallelism in era of halfway items and their summation is acquired utilizing Urdhava Triyagbhyam. Increase strategy assumes vital part in outlining of FIR channel [10]. This sutra can be summed up for any N x N bit augmentation. Figure 1 represents the line outline for the duplication utilizing Urdhava Tiryagbhyam strategy.

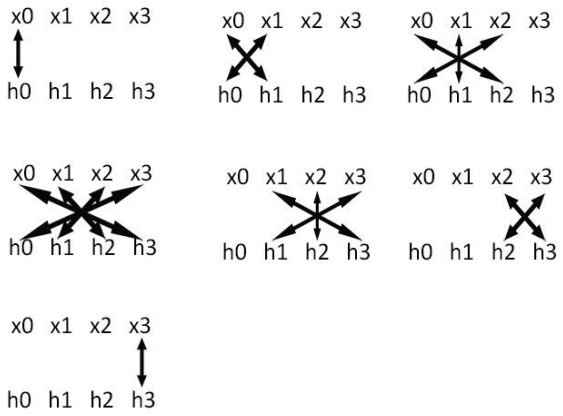

Fig 1. Urdhava Tiryagbhyam Method

IV. FIR FILTER DESIGN APPROACH

The direct form realization of FIR filter can be obtained byusing linear convolution. Consider FIR filter having impulse response h(n) as represented in Figure 2.

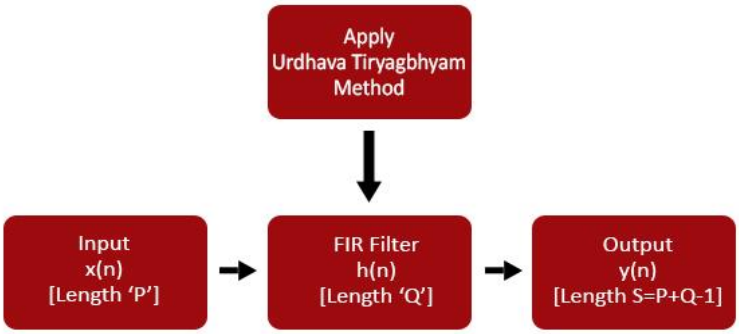

Fig 2. FIR Filter

Let x (n) = Input sequence of a length 'P'.

x (n) = {0, 1, 2, … , P – 1}

h (n) = impulse response of a filter having length 'Q'.

h (n) = {0, 1, 2, … , Q – 1}

The linear convolution of x (n) and h (n) produces the output sequence y(n) and the length of y(n)

S = P + Q -1

The length of x (n) and h (n) can be made equal to 'S' by adding required number of zeros in x (n) and h (n). This is known as zero padding. It means we have to increase the length of x (n) by P points and length of h (n) by Q points to make the total length 'S = P + Q – 1'. In FIR filter, both the sequences x (n) and h (n) are finite, so linear convolution [11] will be finite. The convolution having input x of length P with filter h of length Q will give the output sequence y (n).

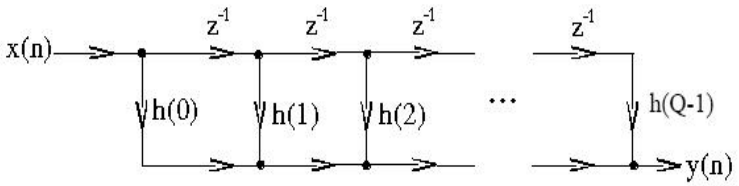

Fig. 3 Direct form structure of FIR system

Figure 3 represents direct form structure of FIR filter. By expanding equation (2) we can draw the direct form structure of FIR filter.

$y(n) = h(0)x(n) + h(1)x(n-1) + h(2)x(n-2) + h(3)x(n-3) + \ldots\ldots\ldots + h(Q-1)x(n-Q+1)$

The direct form realization structure is also called canonic structure since the number of delay elements in the block diagram is equal to the order of difference equation of a digital filter. The above figure contain 'Q – 1' delay blocks. This structure has 'Q – 1' additions and 'Q' multiplications.

V. PROPOSED METHOD

Yield grouping of FIR channel is processed by the straight convolution of its info arrangement and channel coefficient. Since we need to choose the FIR channel of request 36 and 48, subsequently channel has 36-point and 48-point info succession and coefficients separately.

The outline technique of FIR channel with the assistance of Urdhava Tiryagbhyam strategy is represented by Figure 1. For FIR channel of request 4,

Input sequence x(n) = [x(0), x(1), x(2), x(3)]
Filter coefficient h(n)=[h(0), h(1), h(2), h(3)]
The length of input sequence x(n) = P = 4
The length of filter coefficient h(n) = Q = 4
The length of output sequence y(n) =P + Q – 1 = 7
From Urdhava Tiryagbhyam method in Fig. 1,
y(0) = x(0)*h(0)
y(1) = x(0)*h(1) + x(1)*h(0)
y(2) = x(0)*h(2) + x(1)*h(1) + x(2)*h(0)
y(3) = x(0)*h(3) + x(1)*h(2) + x(2)*h(1) + x(3)*h(0)
y(4) = x(1)*h(3) + x(2)*h(2) + x(3)*h(1)
y(5) = x(2)*h(3) + x(3)*h(2)
y(6) = x(3)*h(3)
Above equations gives the output sequence of FIR filter. Thus
y(n) = [y(0), y(1), y(2), y(3), y(4), y(5), y(6)]
This method is applied to any value of N order FIR filter. Now for example if we have FIR filter of order 4 with input sequence
x(n) = [1, 2, 3, 4] and
filter coefficient
h(n) = [3, 32, 46, 16],

then output sequence y(n) of FIR filter is given by
y(0) = 1*3 = 3
y(1) = 1*32 + 2*3 = 38
y(2) = 1*46 + 2*32 + 3*3 = 119
y(3) = 1*16 + 2*46 + 3*32 + 4*3 = 216
y(4) = 2*16 + 3*46 + 4*32 = 298
y(5) = 3*16 + 4*46 = 232
y(6) = 4*16 = 64

y(n) = [3, 38, 119, 216, 298, 232, 64]

VI. RESULT ANALYSIS

A graphical client interface (GUI) window is outline to demonstrate the aftereffects of Vedic strategy regarding the ordinary (inbuilt) strategy. GUI [12] has more prominent impact in the zone of programming application programming which give human PC cooperation. GUI is a simple approach to control data and present information. Its point is to expand the proficiency and usability for the legitimate outline of a put away program. The blend of advancements and gadgets utilizes GUI to give a stage to the client to collaborate with the product for the undertakings of gathering and delivering data.

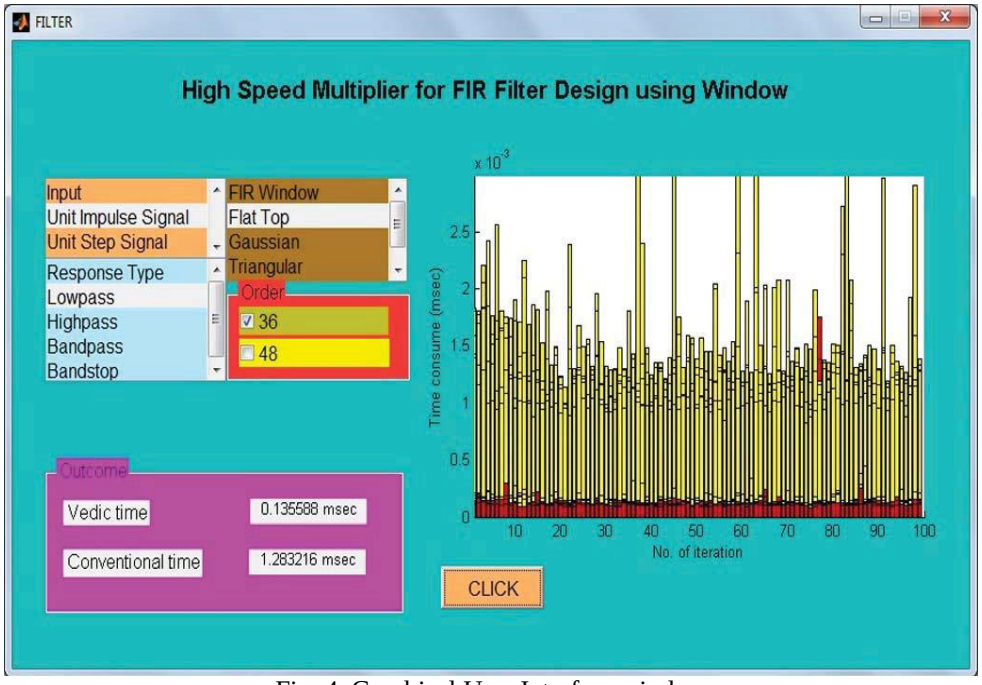

Fig. 4. Graphical User Interface window

Figure 4 represent GUI window for planning FIR channel in which Low pass reaction sort, Flat Top window, and request 36, unit drive signal as info is chosen and as needs be normal execution time is appeared for proposed and traditional technique. GUI likewise indicates visual chart in which red bar speaks to Vedic strategy (proposed) normal time while yellow speaks to traditional technique (Inbuilt) normal time.

The coefficient of FIR channel is created with the assistance of MATLAB device are traded as marked 16-bit whole number. The planning results by Urdhava Tiryagbhyam sutra and inbuilt capacity of MATLAB are processed in Intel Core 2 Twosome processor. Table I – IV speaks to normal time examination between Vedic strategy and routine technique for various request, FIR window, reaction sort and info signal. As appeared in Table I – IV, correlation propose that the execution time taken by Vedic strategy is less when contrasted with traditional technique. Along these lines Urdhava sutra of Vedic strategy turned out to be speedier as contrast with ordinary technique. Figure 5 – 8 indicates yield reaction of FIR channel. For Low pass and High pass FIR channel, 100 kHz inspecting recurrence and 25 kHz cutoff recurrence is taken while for Band pass and Stop band, 20 kHz lower cutoff recurrence and 30 kHz higher cutoff recurrence is taken.

A. For 36 order FIR filter with input as unit impulse signal

Table I. Conventional V/s Vedic Time in LPF

S. No.	FIR Filter	Vedic Mathematics	Conventional Mathematics
1.	Flat Top	0.13 ms	1.18 ms
2.	Gaussian	0.19 ms	1.50 ms
3.	Triangular	0.18 ms	1.76 ms

Table II. Conventional V/s Vedic Time in Bandpass

S. No.	FIR Filter	Vedic Mathematics	Conventional Mathematics
1.	Flat Top	0.16 ms	1.71 ms
2.	Gaussian	0.18 ms	1.86 ms
3.	Triangular	0.12 ms	1.89 ms

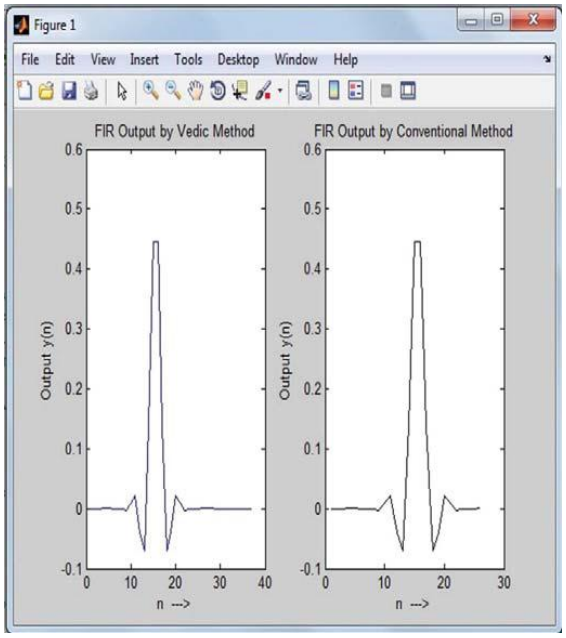

Fig. 5 Output Response of FIR filter-36 order low pass Flattop window

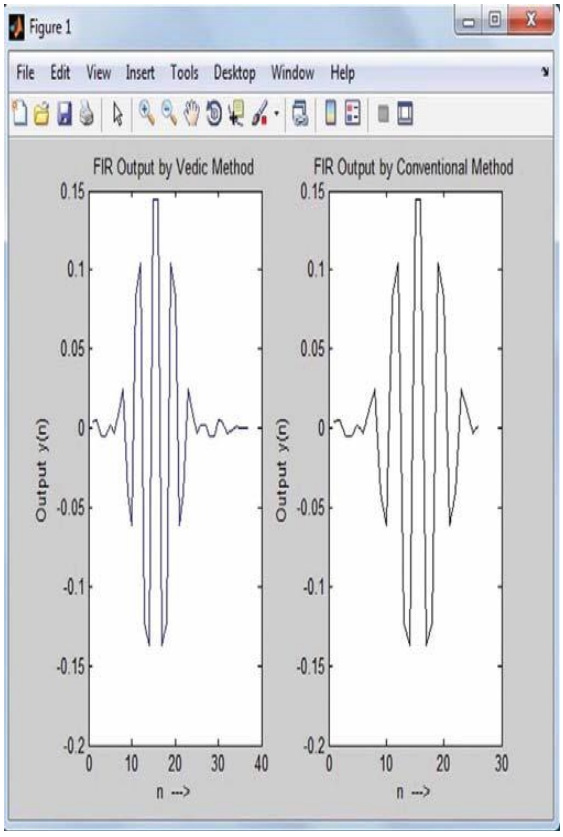

Fig. 6 Output Response of FIR filter-36 order Band pass Gaussian window

B. For 48 Order Fir Filter With Input As Unit Step Signal

Table III. Conventional Versus Vedic Time in HPF

S. No.	FIR Filter	Vedic Mathematics	Conventional Mathematics
1.	Flat Top	0.24 ms	1.38 ms
2.	Gaussian	0.32 ms	1.59 ms
3.	Triangular	0.29 ms	1.56 ms

Table IV. Conventional V/s Vedic Time in Bandstop

S. No.	FIR Filter	Vedic Mathematics	Conventional Mathematics
1.	Flat Top	0.18 ms	1.91 ms
2.	Gaussian	0.22 ms	1.66 ms
3.	Triangular	0.25 ms	1.87 ms

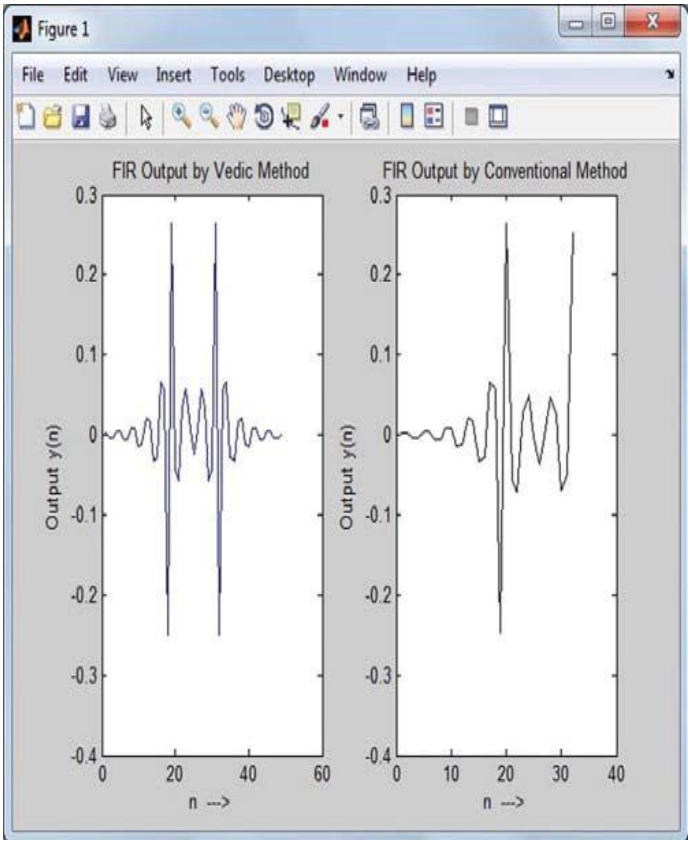

Fig. 7 Output Response of FIR filter-48 order High pass Triangular window

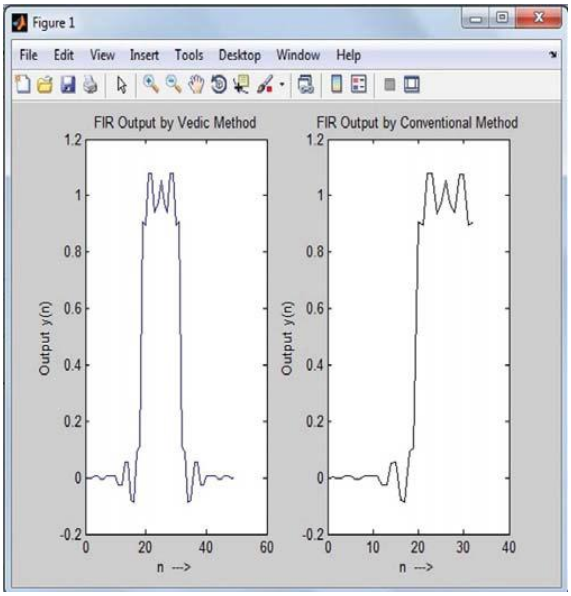

Fig. 8 Output Response of FIR filter-48 order Band stop Gaussian window

VII.CONCLUSION

A FIR filter outline utilizing window is actualized by Urdhava Tiryagbhyam augmentation calculation in Graphical User Interface window. This paper proposed an outline of FIR filter using Vedic strategy. The calculations of Vedic science are significantly more effective than customary arithmetic. It is demonstrated that the Urdhava Tiryagbhyam technique is speedier than the customary strategy for MATLAB. Therefore FIR filter in light of Vedic technique devouring less normal execution time when contrasted with inbuilt functions of MATLAB i.e. time taken for augmentation operation by FIR filter processor is lessened by utilizing Urdhava Tiryagbhyam calculation. Future works using Urdhava Tiryagbhyam strategy can be utilized to enhance the sifting method utilized as a part of picture handling applications and ascertaining the different changes like Fast Fourier Transform (FFTs) and Inverse Fast Fourier Transform (IFFTs). By utilizing these antiquated Vedic sutra world can accomplish higher execution and quality for the new innovation devices.

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