Australian Journal of Basic and Applied Sciences, 8(18) December 2014, Pages: 84-89

AENSI Journals

Australian Journal of Basic and Applied Sciences

ISSN:1991-8178

Journal home page: www.ajbasweb.com

Interframe Video Coding using Fibonacci Spiral Block Matching Algorithm in H.264 Standard

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ARTICLE INFO

Article history:
Received 19 August 2014
Received in revised form
19 September 2014
Accepted 29 September 2014
Available online 12 November 2014

Keywords:
Video Coding, Fibonacci Spiral Search, Compression ratio, Bitrate, Interframe video coding, MPEG-1, MPEG-2, MPEG-4, H.261, H.263 and H.264

ABSTRACT

Video codec with high compression rate is the prerequisite for sending video data through low bit rate communication channels. For accomplishing above mentioned task the streamed video would pass through video coding techniques by reducing the size of the video with no or less quality loss. In this paper we proposed an optimized system; Interframe Video Coding using Fibonacci Spiral Block Matching Algorithm (FSBMA) in H.264 Standard, enforcing this Video codec technique resulted in adaptable compression ratio. Fibonacci spiral search resulted in less number of searching points for further increase the encoding speed rapidly. Subjective performance of individual frame lead to an enhanced picture quality visualize in optimal screen resolution. The simulation results shows that this proposed method can effectively reduce the complexity of interframe encoding, and the quality deprivation is compared with other BMAs with precise bit rate.

To Cite This Article: L.C. Manikandan and Dr. R.K. Selvakumar, Interframe Video Coding using Fibonacci Spiral Block Matching Algorithm in H.264 Standard. ***Aust. J. Basic & Appl. Sci.,*** *8(18): 84-89, 2014*

INTRODUCTION

Digital videos are used in the wide range of applications including DVD, Video telephony, SDTV, HDTV and Teleconferencing (S.Vetrivel *et al*., 2010), (Verbist.F, Munteanu.A, Cornelis.J, Schelkens.P, 2008). For the sequence of frames comprised to form video resulted in various formats. Consider a digital video sequence at a standard definition TV picture resolution of 720 x 480 and have the frame rate of 30 frames per second. If the picture is represented in RGB, it required 3 bytes per pixel and the size of each frame is 720 x 480 x 3 bytes. The disk space required for storing one second of video is 720 x 480 x 3 x 30 =31.1 MB and one hour is 112 GB (G. Sullivan and T. Wiegand, 1998). The bandwidth required to transmit video over wired or wireless networks is 31.1 x 8 = 249 Mbps. Using uncompressed video required high storage and bandwidth, it will add substantial cost to the hardware and systems that process digital video. Video coding is thus necessary for increasing bandwidth and storage capacities. Video coding techniques and standards are based on a set of principles that reduce the redundancy in digital video (Verbist.F, Munteanu.A, Cornelis.J, Schelkens.P, 2008). Several kinds of video and audio compression formats, codecs are MPEG-1, MPEG-2, MPEG-4, H.261, H.263 and H.264 (L.C.Manikandan, Dr.R.K.Selvakumar, August-2014).

In this paper we propose an optimized system, Interframe Video Coding using Fibonacci Spiral Search (FSS) in H.264 Standard. The concept encapsulated here constitute with classic Fibonacci Series in maths, spiral search algorithm dissect the current frame and produce most optimal change in neighborhood frame. The H.264 video coding standard (Zhenzhong Chen, Dongdong Zhang and King Ngi Ngan, 2008), (S.Takamura and Y.Yashima, 2005), (AVCGAS, 2005), (T. Wiegand, G. J. Sullivan, G. Bjontegaard and A. Luthra, 2003) is jointly developed and further modified and appended into scalable video coding where bit-streams with sub-bitstream proficiently confirm the encoded techniques (G. Sullivan and T. Wiegand, 1998). Mathematical parameters to evaluate the code followed as PSNR, Number of Searching Points per Macroblock (NSP/MB) and the Speed-up Ratio are considered and simulation results are compared with Full Search (FS) (S.Vetrivel *et al.*, 2010), (Zhu.S and Ma.K.K, 2000), Diamond Search (DS) (Zhu.S and Ma.K.K, 2000), New Three Step Search (NTSS) (Li.R, Zeng.B and Liou.M.L, 1994), Simple and Efficient Search (Lu.J and Liou.M.L, 1997).

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II. Fibonacci Spiral Block Matching Algorithm (FSBMA):

FSS extract applied for interframe motion vector estimation and residuals evaluated from FSS are luma are deployed into Huffman encoding process. FSS algorithm (L.C.Manikandan and Dr.R.K.Selvakumar, August 2014) considered speed and the whole block search process, the first step started with search point 1, if the block matched then the process will stop else it would move to next step in searching the direction by crosscheck BDM for the neighbourhood four pixels. The consecutive pixel search would lead to the search point more depth into the analysis and search point will follow the Fibonacci sequence from centre point.

2.1 Fibonacci sequence:

Let us begin with the basic definition of Fibonacci Numbers F[n], the recurrence relation F[n+1]=F[n]+F[n-1] with initial conditions F[0]=0 and F[1]=1. It is notice that each number is generated just the sum of the two numbers preceding it. The Fibonacci sequence is the series of numbers: 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, etc.. That is, after the second term, each term is obtained by adding the previous two terms. The 2 is found by adding the two numbers before it (1+1). Similarly, the 3 is found by adding the two numbers before it (1+2), and the 5 is (2+3), and so on (L.C.Manikandan and Dr.R.K.Selvakumar, August 2014).

2.2 The FSS Method and Algorithm:

Fibonacci Spiral can be constructed from an appropriate set of squares. Each block will fit nicely along the edge of the two previous blocks since $F_n = F_{n-1} + F_{n-2}$. It is necessary to keep it rotating around as you add blocks, so the shared edge is at the bottom, right, top and then left edge of the new square. Once the squares are drawn, start spiraling it out from the first square you drew (L.C.Manikandan and Dr.R.K.Selvakumar, August 2014).

Algorithm:

Step1: Current frame (cf) searching block is matched with reference frame (rf) in the same block position. If it is matched, stop the searching process. Otherwise it will match with 4 directional blocks.
Step2: In 4 directional blocks, if any one of the blocks is matched; stop the searching process else we will find the minimum level direction.
Step3: We will find the minimum of 2 values, minimum2 and minimum1 from 4 directions based on this value we fix the direction either clockwise or anticlockwise.
Step4: Next, we will find the matching block with the next Fibonacci level 2 x 2.
Step5: In 2 x 2 levels, there are 4 search points, if any one of the search points is matched; stop the searching process. Otherwise we will move to next Fibonacci level 3 x 3.
Step6: In 3 x 3 levels, we fix the optimal level and select the best matched optimal block and stop the searching process

From which two minimum values will be evaluated and used in prediction of direction. The block matching is the concept underlying between splitting of the current and pre-processed frame with different number of blocks. Next level 2 x 2 search points will be used for MAD calculation and it will exceed up to the final level of Fibonacci series until which the block gets matched. In the worst criteria for the comparison of image m x n, total search points of 15 is more than enough to come out of the search loop. The search points are comparatively less to other block matching algorithms.

III. Methodology:

The whole process of video codec has comprised of broad classification encoding and decoding procedure. In video coding process, the encoding algorithm is applied to the source video to create the compressed file. To play the compressed file, the inverse decoding algorithm is applied to produce a video that shows the same content as the original source video. A pair of algorithms that works together is called a video codec (encoder/decoder) (L.C.Manikandan and Dr.R.K.Selvakumar, September 2014), (S.Takamura and Y.Yashima, 2005). Both the process has splitted into two different sections.

3.1 Encoding Process:

The encoding process initiated with conversion of videos into frames. The frame conversion has fixed frames to simple two dimension matrix of intensity values. Because of RGB components, three layers bind on each other and further more steps of conversion would follow it. Figure 3.1 shows the Encoding Architecture of FSBMA.

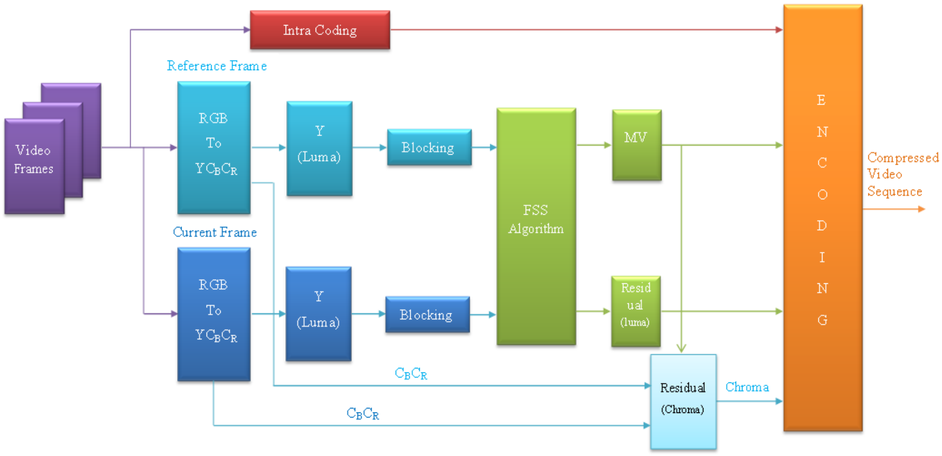

Fig. 3.1: Encoding Architecture of FSBMA.

In the encoding procedure, videos are split into frames, the foremost one fixed as the reference frame, consequently the RGB to YCbCr conversion (L.C.Manikandan and Dr.R.K.Selvakumar, August 2014), (Lu.J and Liou.M.L, 1997) applied for reference and successive frame respectively. The conversion equation is referred as 3-1, 3-2 and 3-3

$$Y= 16 + (65.481R' + 128.553G' + 24.966B') \quad 3\text{-}1$$
$$CB = 128 + (-37.797R' – 74.203G' + 112 B') \quad 3\text{-}2$$
$$CR = 128 + (112R' – 93.786G' – 18.214B') \quad 3\text{-}3$$

Specifically the Y (luma) layer extracted out for Fibonacci Spiral Search (FSS) algorithm leaving CbCr component. In such a way two parallel processes are employed in fore coming encoding phenomena. The residual values would result in the production of difference between reference and current frame. The residuals of CbCr layers, chroma values are estimated and compiled with motion vector estimation and separately deployed into Huffman coding process resulted in compressed video sequence. Figure 3.2 shows the Fibonacci Spiral Block Matching Algorithm Architecture.

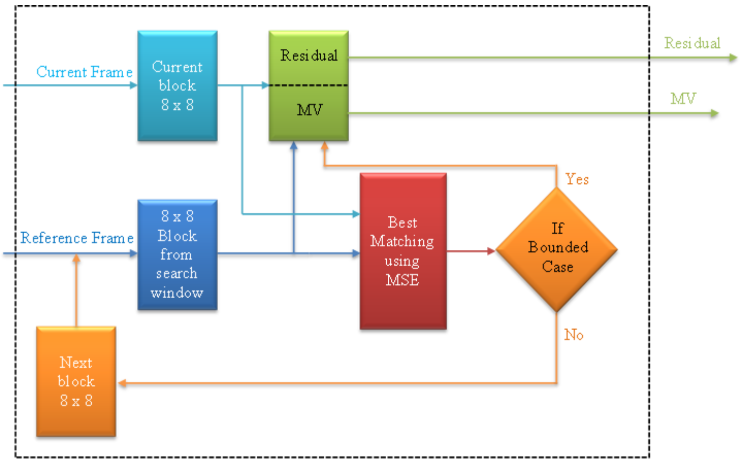

Fig. 3.2: FSBMA Architecture.

In Figure 3.2 the current frame block is compared with the reference frame block within the search window using MSE. If it is bounded it produce MV value else the next block of reference frame is compared with the current frame block. This process will continue until the best match block will found. Then the MV value, residual of current frame and the reference frame are transferred to the encoding process.

In interframe video coding the compression is applied to a sequence of video frames, rather than a single picture/image. In general, relatively little changes from one video frame to the next would occur. An interframe compression exploits the similarities between successive frames and reduces the redundancy error to maximum limit. The above said redundancy check is known as temporal redundancy check, to reduce the volume of data required to describe the sequence.

3.2 Decoding Process:

Once the compressed video sequence incurred in receiving side, decoding process get initiated. In decoding major and preliminary step is splitting up of two different residual frames and motion vectored frame. The reverse process of Encoding would followed by predicted motion vectors correlated with Luma Residual and Chroma Residual from which the original frame has restored.

Further split up of Motion vector data with that of Luma Residual and Chroma Residual. Then combination of reference frame reconstructed with split ups and results in retrieving original data. Reference frame based for reconstruction process resulted in uncompressed video. Figure 3.3 shows the Decoding architecture of FSBMA.

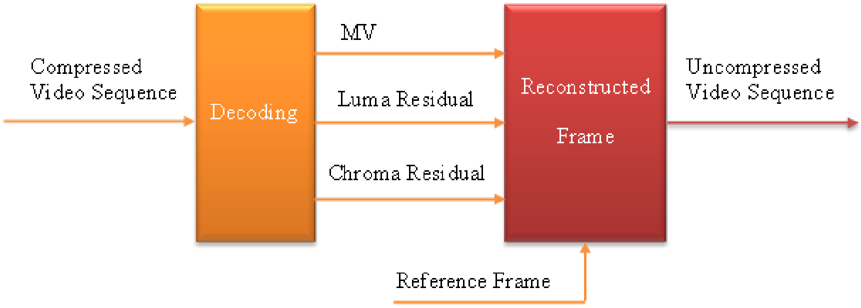

Fig. 3.3: Decoding Architecture of FSBMA.

IV. Result Analysis:

In the evaluation parameter, focused on certain criteria resulted in best experimental results comparing to other block matching algorithms. From generalization to specific search algorithm, the NSP/MB and the Speed-up ratio are comparatively high and achieve the similar quality of the video sequences. To verify the proposed FSBMA algorithm, we tested several MPEG sequences of Foreman, Football, Flower Garden and Mobile and are simulated to evaluate in 8 x 8 block and search window size of ±7, for first 50 frames of sequences. Table 4.1 shows the simulation results for FSBMA and other BMA's (B.G.Kim, S.T.Kim, S.K.Song and P.S.Mah, 2005).

Table 4.1: Simulation results for FSBMA and other BMA's.

Video Sequence	Algorithm	PSNR(dB)	NSP/MB	Speed-up Ratio
Foeman	FS	37.98	225.00	1
	DS	37.67	17.08	13.17
	NTSS	37.33	22.22	10.12
	SES	36.43	13.85	16.24
	FSBMA	32.13	10.52	22.02
Football	FS	26.78	225.00	1
	DS	26.49	18.11	12.42
	NTSS	25.97	23.00	9.78
	SES	25.73	14.03	16.03
	FSBMA	26.60	8.89	26.29
Flower Garden	FS	30.17	225.00	1
	DS	29.83	18.23	12.34
	NTSS	28.77	24.18	9.30
	SES	26.38	13.02	17.28
	FSBMA	22.72	9.97	22.59
Mobile	FS	27.251	225.00	1
	DS	27.142	14.40	15.62
	NTSS	27.171	19.71	11.41
	SES	26.84	15.37	14.63
	FSBMA	21.56	12.03	18.78

From the Table 4.1, it's clearly defined that FSBMA is predominant of FS, DS, NTSS and SES block matching algorithms. The PSNR value are comparatively similar than FS, DS, NTSS and SES block matching algorithms. The Number of Searching Points per Macroblock (NSP/MB) is lesser than other block matching algorithms. Figure 4.1 shows the performance evaluation of Number of Searching Point per Macroblock. It would directly impact in increasing the speed of block matching process. The speed-up ratio is rapidly increased. The performance evaluation of Speed-up Ratio is shown in Figure 4.2.

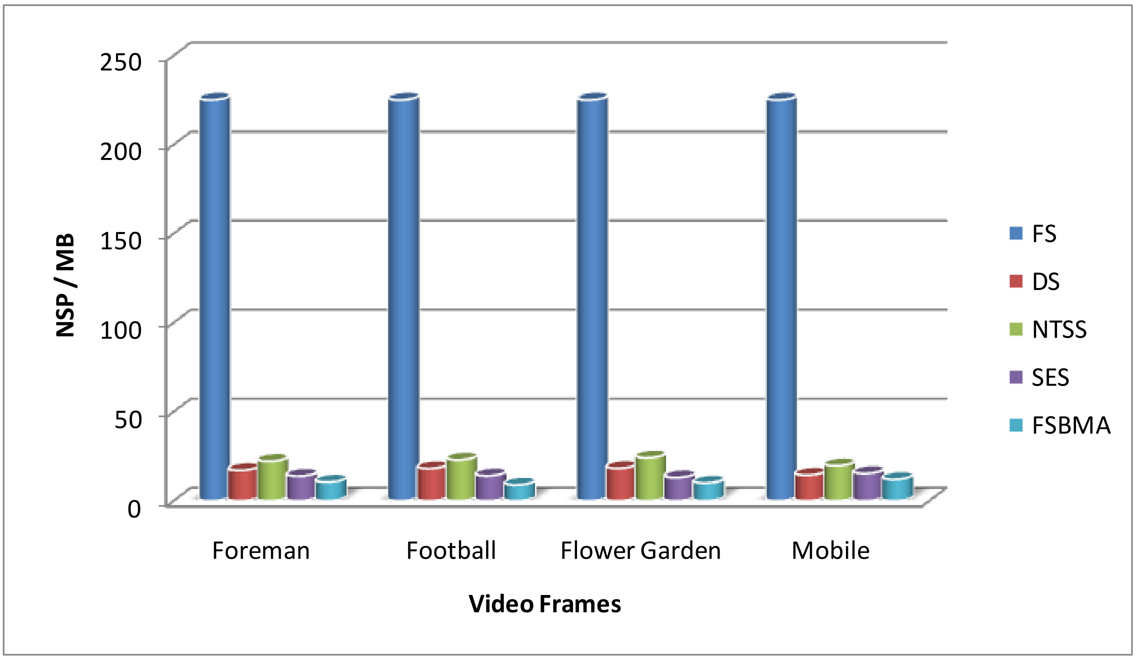

Fig. 4.1: Performance of NSP/MB.

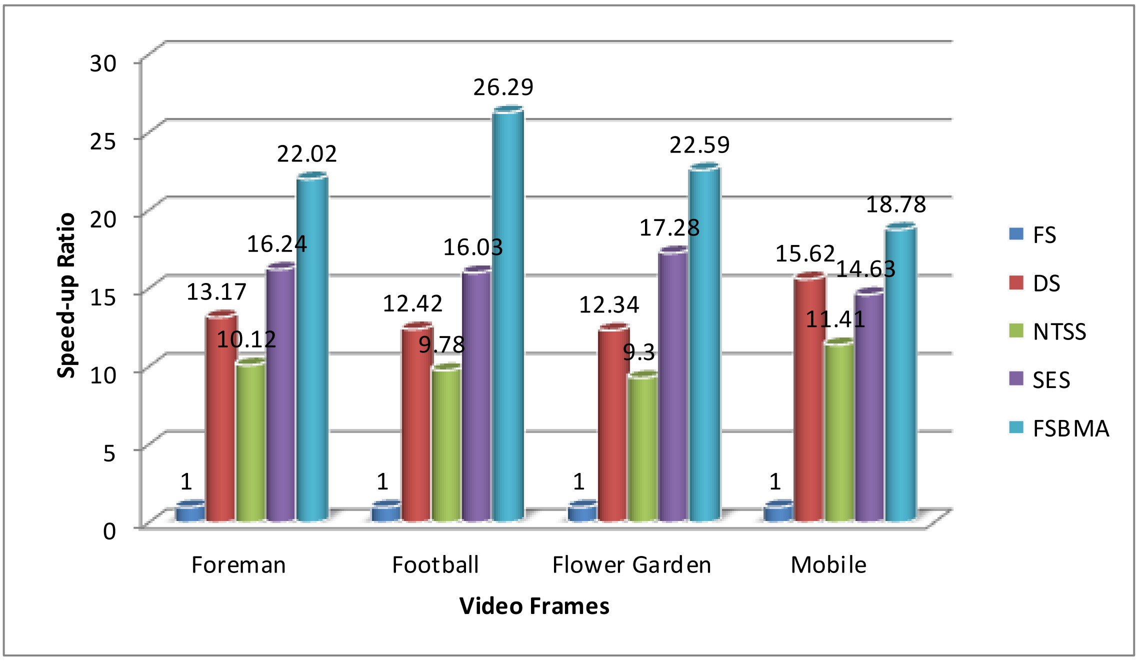

Fig. 4.2: Performance of Speed-up Ratio.

V. Conclusion:

In this paper, H.264 video codec of certain existing methods are examined. Based on these examines and annotations, Interframe Video Coding Using Fibonacci Spiral Search in H.264 Standard is implemented. Evaluated data result shows that the duration for searching points in data compression is occurred in better by inhibited less number of search points. Our evaluation is based on measuring processing speed and quality by defined qualities such as PSNR, NSP/MB and Speed-up Ratio. The proposed Video Coding using Fibonacci Spiral Search algorithm effectively increases the searching process speed and provides similar or better quality.

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