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Parallel Hybrid Fractal Video Coding Technique

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Abstract— ***Fractal video coding technique provides many advantages such as fast decoding , resolution independence and good compression ratio, but is lagging behind because of only one disadvantage which is very high encoding time. To minimize the encoding time, new hybrid technique is implemented. The proposed system combines fractal encoding with Discrete Wavelet Transform to reduce the encoding time. Which reduced the encoding time to a very large extent. The hybrid algorithm is executed in parallel, which again reduced the encoding time and gives good speed up when compared with original algorithm. Use of hybrid technique degrades the quality of video but gives a very good speed up. OpenCL language is used for implementation.***

Keywords— ***Fractal Video Coding, Discrete Wavelet Transform , Hybrid video coding , Parallel Computing***

I. INTRODUCTION

Over the past decades, video compression technologies have become an integral part of our life. It depicts the way we create, communicate and consume visual information. Many applications such as broadcast services over satellite, digital video storage and other services which uses digital video communication. The data quantity of the digital video is very high and the memory of the storage devices and the bandwidth of the transmission channel are not infinite, so if the amount of data needed to reproduce video is reduced then it saves storage space and increases access speed and is the only way to achieve motion video on digital computers. Encoding techniques reduce redundancy within an image and video so that the amount of data sent over a channel can be minimized.

Fractal Video encoding technique is based on self-similarity in real-world images ,where an image is modelled as the unique fixed point of a contractive operator on space of images[1]. Fractal video coding technique is now compared with well established techniques like Discrete Cosine Transform (DCT) and new emerging techniques like wavelets. Only disadvantage of Fractal is high encoding time(where as decoding is very fast) compared to transform coding. But provides good image quality after reconstruction.

To overcome the drawback of fractal coding technique two ways are developed . First way explains how Discrete Wavelet Transform technique is combined with fractal coding and second way explains how encoding part is executed in parallel. Using both ways experimental results shows better results.

II. FRACTAL IMAGE COMPRESSION

A Fractal is a structure that is made up of similar forms and patterns that occur in many different sizes. Fractals are also defined as objects with fractional dimension[2]. A fractal is a mathematical set that typically displays self similar patterns[3]. Fractals may exactly same at every scale or they may be nearly the same at different scales[4]. It uses the concept of attractor. Attractor is a set of physical properties toward which a system tends to evolve, regardless of the starting conditions of the system.

Fractal uses the concept of Contractive transformation, Iterated Function System(IFS) and Fixed Point. The given transformation is said to be contractive if it is applied to any two points in the input must bring them closer together in the output[2]. An IFS consists of a collection of contractive transformations $\{w_i : R^2 \rightarrow R^2 \mid i = 1,..., n\}$ which map the plane R^2 to itself This collection of transformation defines a map

$$W(.) = \cup_{i=1}^{n} w_i(.) \qquad (1)$$

The map W is not applied to the plane , it is applied to sets - that is, collections of points in the plane. Given an input set S, we can compute w_i for each i , take the union of these sets and get a new set W(S)[2].

As real time images are not exact self similar, so the images are partitioned into non overlapping blocks called as range blocks. These blocks are mapped to overlapping blocks which are double the size of range blocks called domain blocks. By using metrics like RMS, the error between two blocks(range and domain) as well as contrast and brightness values are calculated. For this error calculation process ,each range block is compared with all domain blocks. The domain block for which minimum RMS error is calculated , is stored along with contrast and brightness in the encoded file of a particular range bock. The time required to find the matching domain block is very high, so researchers had been working on it. Here the use of hybrid and parallel techniques comes.

While decoding the image , basis image is considered(which can be blank image or any other image). Encoded details of each block are fetched from encoded file and applied to particular domain block. This procedure is followed until the image converges. The decoding process of Fractal is very fast.

III. PROPOSED PARALLEL HYBRID FRACTAL VIDEO CODING TECHNIQUE

Proposed algorithm is developed in four stages. And all stages are dependent on each other.

A. Discrete Wavelet Transform(DWT)

When we apply DWT on an image, approximate and detailed coefficients are separated using sub band coding and image is divided into four parts which are LL, LH,HL and HH. From which LL part gives approximate values of whole image where as HH part give detailed part of the image. Here LL part gives us low frequency components of the image and HH part gives high frequency components. Which part is more important for processing depends on the application and image data. In DWT algorithm uses sub band coding functions. In sub band coding low pass and high pass filters are used. After application of DWT, we consider LL part of the image as it contained approximate values.

The function for sub band coding of an image is taking the average and difference. It is implemented by applying the average function firstly along rows and then along columns. The other way it is implemented is by taking the average of 2x2 block of that image and detailed coefficients are calculated by taking average of 2x2 blocks difference. In our project we have considered only approximate coefficients. After applying Dwt the size of image is decreased by 4. While applying Inverse DWT, we are copying the value of a pixel to the 2x2 block.

B. Proposed Sequential Hybrid Fractal+ DWT Video Coding

In fractal video coding ,each frame in a video is divided into non overlapping blocks called *range blocks* and overlapping blocks called *domain blocks.* Domain blocks are double the size of range blocks. For simplicity in calculating the RMS proposed method uses **domain pool** concept. Domain pool means instead of fetching each domain block for each range block all domain blocks are created before the mapping of range and domain starts. Which reduced the encoding time by some milliseconds. For example If we consider an image of size 256x256 and range block size as 8 then No of range blocks = (256/8)* (256/8) =1024 and No of domain blocks = (256-16+1)* (256-16+1) = 58081(with step size = 1)and each domain block 8 affine transformations are applied. So total number of domain block = 58081*8= 464648. For each of the 1024 range blocks 464648 domain blocks are searched to get the best domain block match. This is the only reason the encoding time of fractal video coding is very high. To reduce this time complexity many methods like domain classification are proposed. But if we reduce the number of domain blocks so that the whole image is also covered and the time required to find best match is also reduced. So in proposed method the step size is considered to be greater than 1, which reduces the number of domain blocks to a very large extent. For the above example: we consider the step size =16. No of range blocks = (256/8)* (256/8) =1024 and No of domain blocks = (256/16)* (256/16) = 256 and with its all 8 transformations Total number of domain block = 256*8=2048. Which results in very high speed up. And it does not affect much on the quality of the frame.

1) Modified Fractal Video Encoding

- Accept a video as input
  - Extract frames from the video
  - Set a threshold value for rms calculation
- Apply DWT on each frame
- Take range size and step size as input from the user
- Partition each frame into range blocks(non overlapping).Here ranges (r) and domains (d = 2*r)
- Generate Domain pool (**With Step size provided by user**)
  - Apply spatial contraction on each domain
  - Apply affine transformation on each contracted domain
  - Store all transformations of each domain block
- Search for most suitable domain block. Compute (s, o, rms)
  - If value < threshold then store the domain information
- If value > threshold then domain with least value of rms is the best matching block for the range
- Store the fractal code for the same
- End

2) Modified Fractal Video Decoding

- Read range and domain mapping (i.e. coordinates x & y and its height and width also the offset and scaling values) in encoded file
- Take a blank image
- Get the locations of domain and range by placing the coordinates from encoded file
- Then shrink this domain to the size of range
- Multiply scaling and add offset to this shrunken domain
- Replace this shrunken domain to the range, which maps to it. This is the first iteration
- Again repeat this by multiplying scaling and adding offset to the same iteratively till some predefined number of iterations preferably 25
- Apply Inverse DWT
- Calculate PSNR between this image and original image
- End

C. Proposed Parallel Hybrid Fractal+ DWT Video Coding

Parallel programming for proposed algorithm is implemented on OpenCL structure. OpenCL is chosen as it is open source, cross platform language used for heterogeneous computing. OpenCL application can execute on CPU as well as one or more GPUs. The tasks which can execute faster when executed sequentially should be assigned to CPU and the tasks which are computationally more expensive should be executed on GPU. The selection of the device (CPU/GPU) should make sure that each process is busy doing tasks assigned to it. Data should be transferred from host processor to device processor for execution. For some applications transfer time is very significant portion of total execution time. So the applications should be designed to minimize this time. Algorithm for proposed system can be explained as follows

1) Parallel Hybrid Fractal+ DWT Video Encoding

- Accept a video as input.
- **Apply DWT** on each frame.
- Take range size and step size as input from the user.
- Partition each frame into range blocks(non overlapping) , called as range pool. Here ranges (r) and domains (d = 2*r).
- Generate Domain pool (**With Step size provided by user**).
- **Send** this domain and range pools to **device**.
- Set number of work items = number of range blocks(so that each block is executed in parallel).
- Search for most suitable domain block. Compute (s, o, rms).
- If value > threshold then domain with least value of rms is the best matching block for the range.
- Copy the stored values to host.
- Store the fractal code.
- End.

IV. EXPERIMENTAL RESULTS

The experimental results as shown in Fig. 1 are obtained by considering 20 frames of a video. The videos tested are of size 256x256. The results are tested for interframe videos.

- The experimental results show that Simple fractal encoding with range size 4 gives best quality.
- Hybrid structure does not give good PSNR for both range sizes 4 and 8.

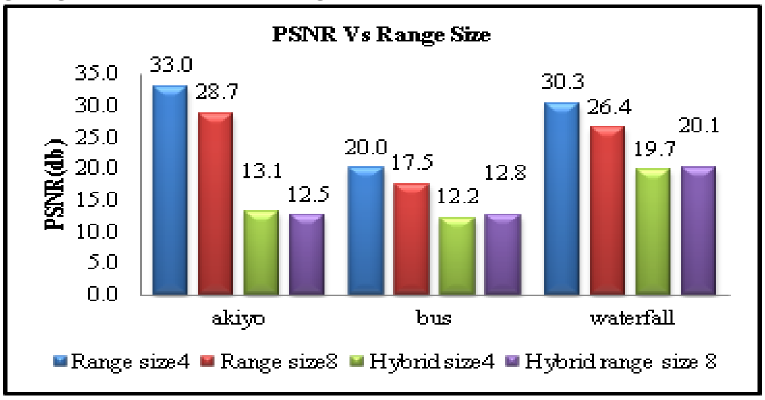

Fig. 1: PSNR Vs Range Size

- The experimental results as shown in Fig. 2 shows that Higher the range size higher the compression ratio.
- Simple fractal Intra frame encoding gives a lower compression ratio.
- Hybrid interframe encoding gives the highest compression ratio.
- Sequential and parallel encoding gives the same compression ratio.

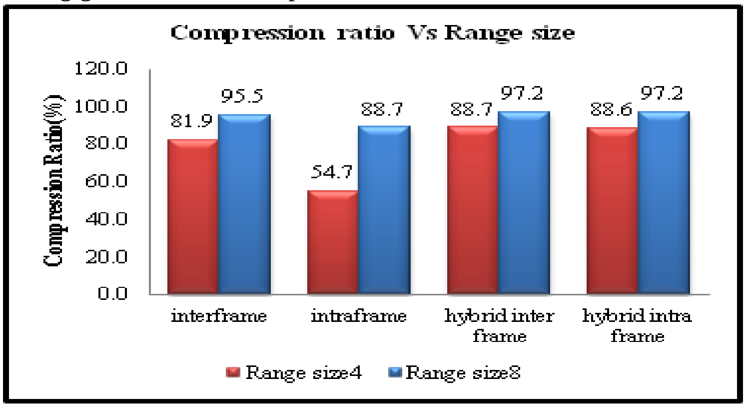

Fig. 2: Compression Vs Range Size

- The experimental results as shown in Fig.3 shows that for simple fractal encoding the parallel processing gives good performance gain
- But for parallel hybrid fractal video coding performance gain is not achieved. This occurred because of the data transfer overhead.
- Also some part of the code (ex. calculating minimum RMS between all domain blocks) is inherently sequential. This part of code will take the same time in sequential as well as in parallel execution.
- Total encoding time required using parallel structure is very good as compared original fractal encoding algorithm.

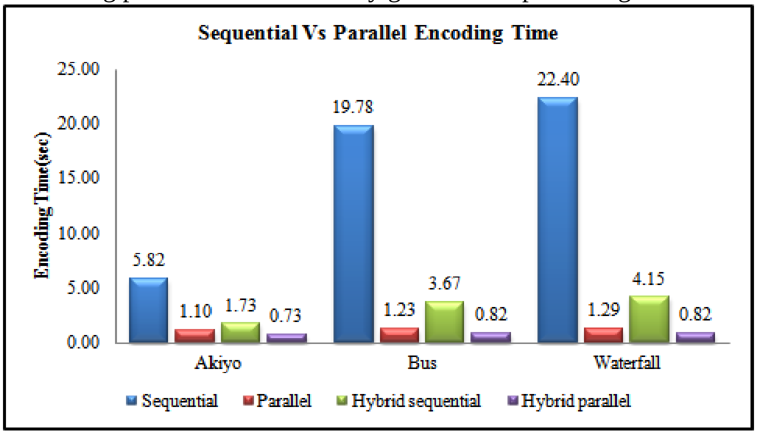

Fig. 3: Sequential Vs Parallel Encoding Time

Speed up is tested on NVIDIA GeForce GTX 660. Speedup is calculated by executing the program sequentially and then in parallel. Number of cores launched are 256 , 1024 and 4096 respectively.

- The experimental results as shown in Fig. 4 shows that as we increase the number of work items the speed up is increased.
- Speedup is directly proportional to the number of work items launched.

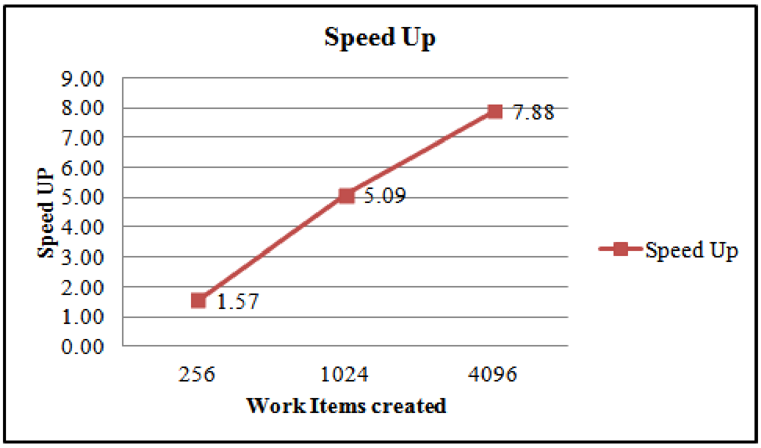

Fig. 4: Speedup

V. CONCLUSIONS

The high computational time complexity of fractal encoding technique can be successfully reduced by using Discrete Wavelet Transform combined with traditional fractal coding . Making execution of domain, range mapping in parallel also helped to reduce the time complexity.

- Using threshold value encoding time is reduced to a very large extent and quality is degraded to a very small extent.
- Using lattice spacing also encoding executed very faster. If we take lattice spacing of domain size then the encoding time required is minimized and quality is degraded to a very small extent.
- Applying dwt gives a very good speedup, but quality is degraded at very large extent.
- Making the proposed system gives better speedup and each frame is encoded as an average 0.7 sec which is very good compared to traditional fractal encoding.
- Using more powerful GPU can give more good speed up.

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