Image Compression Algorithms using VHDL Techniques

Meera Negi, Ruchi Sharma
Department of Electronics and communication Engineering,
Vivekananda Global University , Jaipur, India.

Abstract - **This paper presents an image, done its unique form, holds enormous sum about information which requests not just expansive add up about memory prerequisites for its stockpiling as well as makes badly arranged transmission over constrained data transfer capacity channel. It may be performed for steps for example, such that picture transformation, quantization Furthermore entropy coding. JPEG may be a standout amongst the The greater part utilized picture squeezing standard which employments discrete cosimo the senior convert (DCT) and DWT convert the image from spatial with recurrence Web-domain. An image holds low visual majority of the data Previously, its helter skelter frequencies to which overwhelming quantization could a chance to be finished so as to decrease the extent in the converted representational. Entropy coding takes after with further lessen those excess in the converted What's more quantized picture information. Those suggested investigate worth of effort will be kept tabs on the effective fittings execution for change based image compression calculations Eventually Tom's perusing upgrading those building design of the framework. Convey math (DA) is a proficient approach will actualize all the advanced sign transforming calculations. Da will be acknowledged by two separate ways, you quit offering on that one through capacity for recomputed values done RAMs furthermore an additional without ram necessities. Ram allowed DA will be additional productive. The modifying for VHDL will be intricate at it is fisible for advanced preparing straightforwardly.**

Key words: Discrete wavelet transform (DWT), DCT,VLSI design, testbench.

INTRODUCTION

An image clinched alongside its unique representational carries enormous sum about information. Thus, it obliges extensive measure for memory for stockpiling [1]. Image comperession will be a paramount range for image transforming which effectively removes the outwardly inconsequential information [2–8]. Compressed pictures need aid sent again set data transfer capacity channel for exactly extra transforming to hearty (error free) transmission [9–12]. Transform based image compression calculation is a most preferred choice which consists of image transform (in non-overlapping blocks), quantization of transformed coefficients and entropy coding . The greater part favored decision which comprises for picture convert (in non-overlapping blocks), quantization for converted coefficients Also entropy coding [13]. Joint photographic master gathering (JPEG) may be An council that standardizes those picture squeezing algorithm [14]. Those 8x8 block-wise two-dimensional discrete cosimo the senior convert (2-D DCT) is utilized Similarly as orthogonal convert to JPEG picture squeezing [15]. Image compacted by this standard are utilized Comprehensively.

This calculation gives those client on pick between measure from claiming layering and personal satisfaction as for every those prerequisite of the picture in distinctive provisions. The variable measure about layering makes this calculation low recurrence suitableness to those transmission reason for existing as client might alter those spot rate of the transmission as stated by channel limit. JPEG will be settled calculation and it need some adaptability that camwood make consolidated undoubtedly without At whatever significant transforms in the essential structural characteristic. JPEG framework camwood make executed clinched alongside product and in addition done equipment. Programming result is not guaranteeing for the requisitions requiring secondary pace. Therefore, continuous-handling may be finished through those committed fittings [19,20]. To custom fittings implementation, building design assumes a basic part to choosing area, energy Furthermore throughput of the configuration. Building design optimizations prompt bring down computational units (adders, multipliers), diminished memory size for capacity from claiming Brief variables Also more diminutive interconnects. Building design explorations with minimize those region Also force utilization will be An issue for compact units running for battery. Low silicon territory diminishes those cosset of the machine [21,22] and low force utilization builds the battery lifetime (time between recharges to chargeable battery) which thus diminishes the weight of the battery and Generally speaking extent [23]. 2-D DCT may be an intricate calculation What's more obliges secondary computations. Further, resulting phases clinched alongside change based picture squeezing oblige helter skelter memory stockpiling alongside math circuits. For convenient devices, Hosting picture squeezing framework (like JPEG layering in computerized Polaroid [24–27]), minimal effort design, that could make attained Toward lessening silicon region may be Exceedingly obliged [28–31]. Toward effectively outlining those fittings architecture, picture squeezing might be performed for minimal effort and low force plan. Target about this paper may be on configuration picture examination utilizing DWT technique.

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International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
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IMAGE COMPRESSION TECHNIQUE

Image of a natural scene need infinite level of brilliance Furthermore color force varieties. A piece from intensity, they need aid constant capacity On two dimensional space. On methodology those picture for Different requisitions Eventually Tom's perusing advanced processors alongside its capacity over memory, image information acquired starting with electronic picture sensors (CCD or CMOS) clinched alongside advanced camera, scanner alternately At whatever comparative gadget need aid changed over under advanced structure Toward A/D converter. Testing Furthermore quantization steps are utilized [1]. Those infinite force level levels of the picture need not with standing ended up advanced Hosting limited levels. Spatial continuity, itself continuously sampled by those altered focuses available on the sensor, is changed over should discrete. Constant image indicator (natural scene), now, may be a two dimensional advanced function, spoke to Eventually Tom's perusing f(x, y), the place the extent about capacity f speaks to the power starting with "around limited levels from claiming intensities In any side of the point (x, y) in the space. Those coordinate (x, y) may be discrete Similarly as shown in fig. 2. 1.
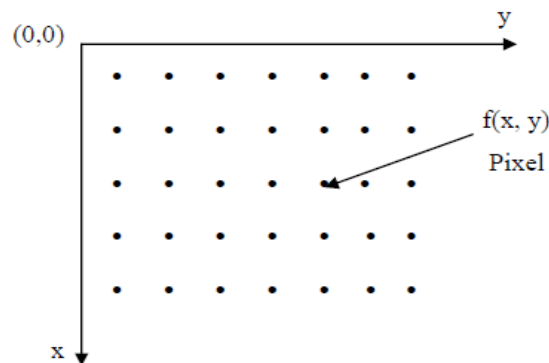

Fig Representation of digital image in two dimensional spatial coordinate

In digital representation, the magnitude of intensity is represented by a fixed number of bits for the entire pixels. Classification of image on the basis of the number of bits used for representing each of its pixel value is as follows [72] (a) Bi-level angel each pixel will accept one bit (binary) value, representing black and white. Textual information can be represented by the bi-level image. (b) Grayscale image This is a most common type of image used in many applications. A grayscale image represents the 2n shades of a gray, where n is the number of bits representing each pixel. The 8-bits (one byte) representation is most preferred and used for display in computer monitor and printing purpose as well. In 8-bit representation there are 256 shades of gray (or intensities) between black and white. (c) Continuous-tone image In a continuous-tone image there are many shades of a color (or gray). In other words,
one pixel has many intensity levels such that nearby pixel intensity, though it differs by one unit intensity level, appears same to the eyes. Images obtained from the digital cameras and scanners are example of continuous-tone image. Color image is represented by 24-bits pixel value in three color component planes R (red), G (green) and B (blue) with 8-bits allocated for intensities of each color.

Image Compression Model
Image compression reduces the amount of data from the original image representation. There are two approaches to compress an image. These are:

(a) Lossless compression

(b) Lossy compression

Fig.2.2 shows a general image compression model. Image data representation has redundancy (also called pixel correlation, interpixel redundancy or spatial redundancy), in the sense, a pixel value can be predicted by its neighborhood pixels [1, 76]. Decorrelation process removes the spatial redundancy and hence, facilitates compression. Some of the techniques used for this process are predictive coding, transform coding and subband coding [76]. Apart from the interpixel redundancy, there is statistical redundancy present in the data after de-correlation (not only image but any data possess statistical redundancy). This is removed by entropy encoding process where more probable symbol is assigned less number of bits and vice-versa (also called variable length encoding). Huffman coding and arithmetic coding are two important techniques used for entropy encoding of data . Although, arithmetic encoding gives slightly

Special Issue - 2017

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
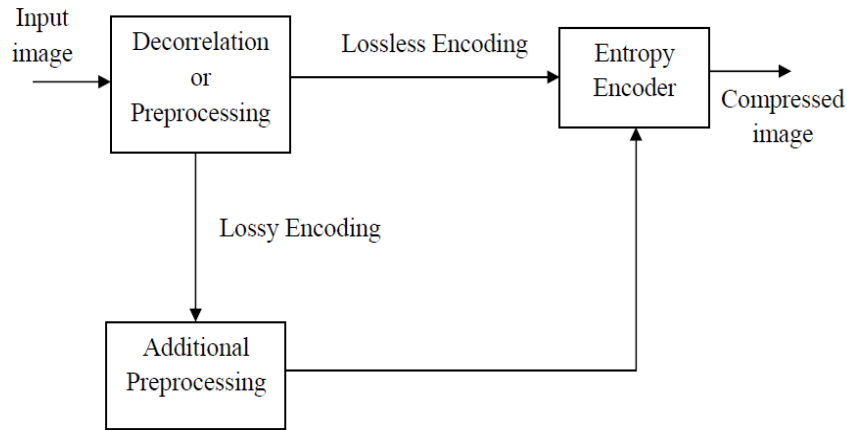**VIMPACT - 2017 Conference Proceedings**

Fig. A generalized image compression model

more compression than the Huffman encoding, it is a more complex and computation intensive. Therefore, Huffman coding is preferred choice in hardware implementation of entropy coding. In case of lossless compression, images undergo entropy encoding directly after de-correlation, whereas lossy compression require additional preprocessing stage called quantization before it is encoded by entropy process. Quantization is irreversible process and it is the only lossy stage in image compression model.

2.5 Transform based Image Coding

Transform based image coding is most preferred and widely used lossy image compression (coding) method. Fig shows the block diagram of transformed based image compression coding technique. The reason for those convert will be to uproot inter pixel excess (or de-correlate) starting with the first picture representational.Those image information will be changed with another representational the place Normal values for converted information would littler over the first manifestation. Along these lines the

layering will be attained. The higher those relationship "around those picture pixels, those superior may be the layering proportion attained. An image transform should have the following properties.

(a) Inverse transformation should exist

(b) De-correlate the original image data

(c) Clear separation of frequency

Inverse transformation is a pre-requisite requirement in any transform because transformed data should be re-constructed for image formation by inverse process (decompression). Orthogonal transform (like DCT, DHT, DWT, etc.) is used for this purpose. A de-correlation property makes the transformed data independent from each other. In lossy image compression, some coefficients are quantized to zero or altered to a new smaller value.
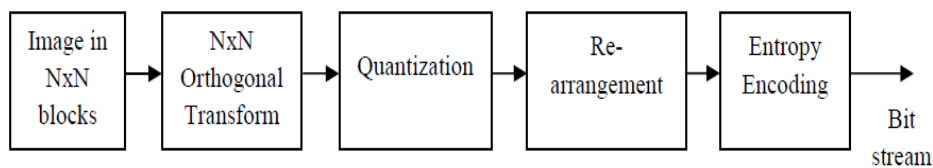
Fig. Transform based image compression model

JPEG baseline Image Coding

JPEG baseline image coding is a transform based lossy image compression technique and it is standardized by JPEG committee [14]. Image is processed in 8x8 blocks to reduce the computational complexity for the

implementation. The 8x8 block-wise 2-D DCT is taken followed by quantization of DCT coefficients. A typical quantization matrix is given by,

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International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
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$$Q_m = \begin{bmatrix} 16 & 11 & 10 & 16 & 24 & 40 & 51 & 61 \\ 12 & 12 & 14 & 19 & 26 & 58 & 60 & 55 \\ 14 & 13 & 16 & 24 & 40 & 57 & 69 & 56 \\ 14 & 17 & 22 & 29 & 51 & 87 & 80 & 62 \\ 18 & 22 & 37 & 56 & 68 & 109 & 103 & 77 \\ 24 & 35 & 55 & 64 & 81 & 104 & 113 & 92 \\ 49 & 64 & 78 & 87 & 103 & 121 & 120 & 101 \\ 72 & 92 & 95 & 98 & 112 & 100 & 103 & 99 \end{bmatrix}$$

Quantized DCT coefficients are rearranged in increasing frequency order (zig-zag order) as shown in Fig 2.4(a) so as to encode the visually significant coefficients first. The first DCT coefficient is having zero frequency. It is called DC coefficient and the rest of the 63 coefficients are called AC coefficient [15]. DC coefficient from the previous block are subtracted with the current block (differential coding) and are encoded using Huffman coding. The DC coefficients represent the average image information of the block. The AC coefficients are first encoded by run-length coding where an AC coefficient and runs of zero preceding this coefficient are grouped. This is performed because most of the high frequency coefficients (residing in bottom right region) become zero after quantization and hence efficient (short) binary code is obtained. The run-length coded data are then encoded by Huffman coding procedure. The JPEG committee provides a standard table for quantization as well as Huffman coding (Fig.2.4(b). Quantization levels are stored in quantization table whereas, Huffman table contains the base codes of the AC and DC coefficients. For getting base code for a coefficient, its category (it is assigned for a range of coefficients [1] and run-length code (for AC coefficients) form the address to fetch the base code from the table. Base code is extended with binary code of the coefficient to make the complete code of the coefficient.
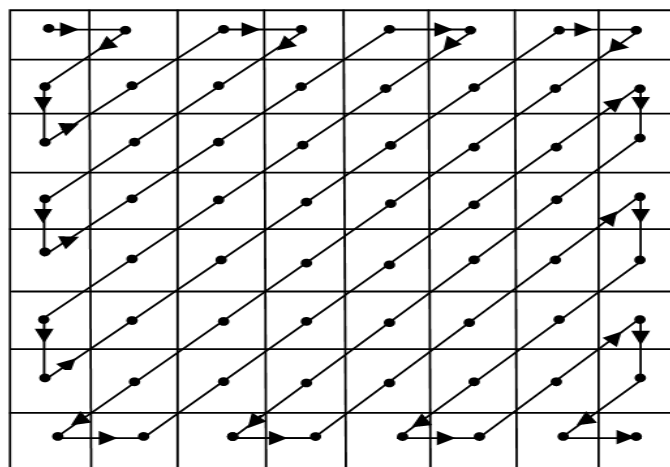
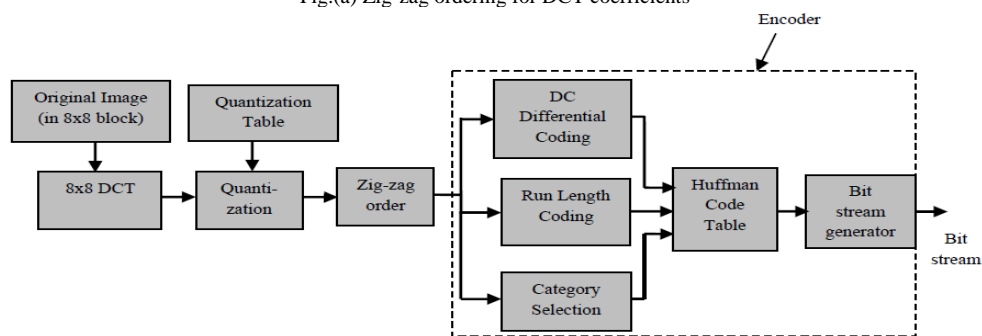

Fig.(a) Zig-zag ordering for DCT coefficients

Fig.(b) JPEG baseline Image compression

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International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
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2.7 Discrete Cosine Transform (DCT)

　　　　DCT is a popular transform domain.DCT uses the cosine transform torepresent original data. Karhunen-Lo'eve transform (KLT) is optimal in class of orthogonal transforms like Fourier transform, Walsh-Hadamard transform and Haar transform and has the best energy compaction [72, 79]. However, KLT is not ideal for practical image compression as its basis vectors has to be calculated according to the pixel values of the image (i.e., KLT is a data dependent). For each image, there will be Encoder 8x8 DCT Quantization Zig-zag order Quantization Table Original Image (in 8x8 block) Bit Stream generator Bit stream DC Differential Coding Run Length Coding Category Selection Huffman Code Table separate basis vectors that also need to be included in the compressed image for the decompression process. It was found that DCT performs close to KLT and their performances are also close with respect to rate-distortion criterion (quality at different compression) [79]. In addition, there are several fast and hardware efficient algorithms available for the computation of DCT [80–87]. Therefore, DCT became the widely used transform for lossy image encoding/compression and also in the several other signal processing applications.
-Do-

　2-D DCT Equation
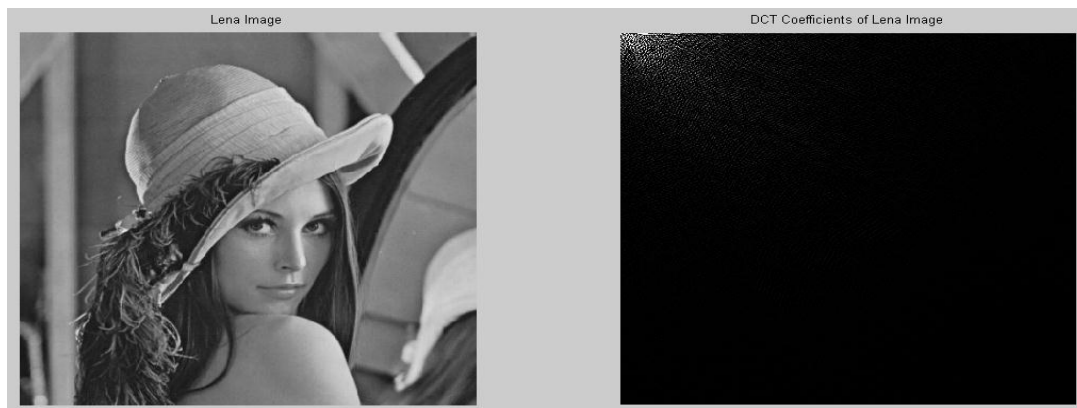For a NxN 2-D data $X(i, j)$, $0 \le i \le N-1$ and $0 \le j \le N-1$, NxN

2-D DCT is given by [64],

$F\ u\ v\ C$

where, $0 \le u \le N-1$ and $0 \le v \le N-1$ and C(u), C(v) = 1/ 2 for u, v=0, C(u), C(v) =1 otherwise. The 2-D DCT equation is separable transform and can be evaluated by first taking the 1-D DCT to rows followed by 1-D DCT to columns, where 1-D DCT is given by,
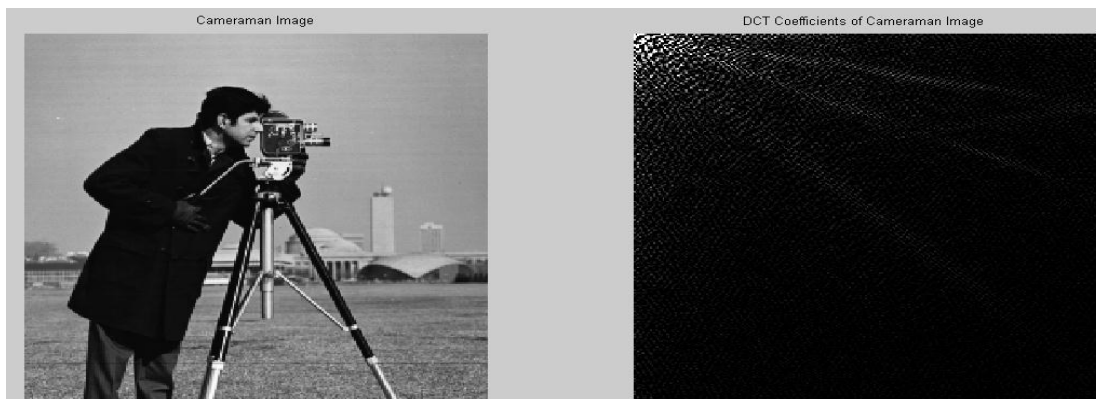
With, C(u) defined as above. Fig.2.5 shows the 2-D DCT calculation from 1-D DCT using separable property. DCT transforms the spatial data into frequency domain.

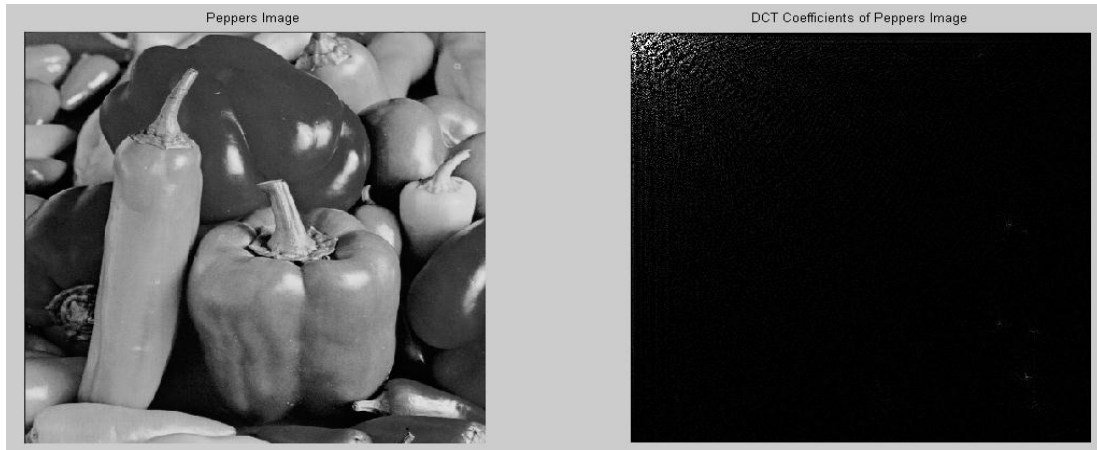Energy Compaction Property of 2-D DCT

DCT has very good energy compaction. Most of the image energy is stored in few DCT coefficients. Images are transformed into 2-D DCT and images of coefficients are displayed in right side for three types of standard images as shown in Fig. 2.7. Top left side is brighter indicating high intensity, i.e., high numerical value of coefficients, whereas, rest of the parts are black that means they have almost zero value (and hence zero energy) as energy is proportional to square of the image intensity.

(a)

(b)

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International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
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(c)

Energy compaction of DCT. Image (left) and its DCT coefficients' image (right) (a) 450x450 Lena, (b) 256x256 Cameraman and (c) 512x512 Peppers

Image Reconstruction by selective DCT coefficients

DC coefficient of DCT contains the average pixel values of the image. This is true for the block based transform as well. In case of block based transform, DC coefficients of each block carry most of the signal energy of that block and therefore, DC coefficients of the image have highest energy as compared to the average energy possess by total AC coefficients of entire blocks. This is shown in Fig.2.8, where Lena and Peppers images are first DCT transformed in 8x8 blocks. Then, AC coefficients of each block is discarded (quantized to zero) and image is reconstructed by Inverse DCT (IDCT) with the help of only DC coefficients of each block. Energy compaction property of DCT coefficients discussed in Sub Section 2.4.2 clarify that most of the image energy is contained in few low order DCT coefficients. This observation can be exploited to reduce the computation of DCT in both hardware and software implementations. Four types of images are JPEG compressed and decompressed in three cases by selectively taking 8x8 DCT coefficients.

Discrete Wavelet Transform (DWT)

The wavelet change has been broadly utilized as a part of the utilization of image processing and a few different applications. Compression, signal analysis and signal processing have been a portion of the applications made practical in this field of study in the previous couple of decades. Despite the fact that a long way from finish, attempt to present couple of fundamental ideas of the DWT for the purpose of this dissertation. A descrete wavelet transform (DWT) is any wavelet transform for which the wavelets are discretely tested. Likewise with added wavelet transforms, a key advantage it has over Fourier transforms is banausic resolution. It captures both abundance and area advice (location in time).To comprehend the fundamental thought of the DWT concentrate on one dimensional signal.

An sign may be part under two parts, regularly secondary frequencies furthermore low frequencies [12]. Those edge segments of the indicator are generally restricted under low frequencies. The edge segments of the sign need aid greater in the high back a piece. The low recurrence a major aspect is Moreover piece under two areas about secondary and low frequency (analysis). This methodology is continued until those indicator need been inside and out decayed alternately ceased When Toward the client. Besides, from the DWT coefficients, the original signal can be changed. The reconstruction process (synthesis) is known as the inverse DWT (IDWT). For some signals, the substance in low-frequency is the most critical part. It is that gives the signal its personality. The high-frequency components, on the other side, gives flavor or subtlety. Consider the human voice.
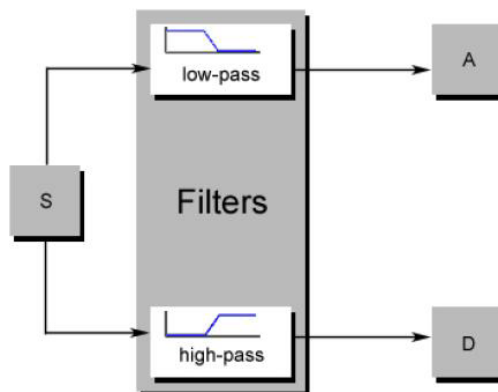

Fig : Filtering or decomposition process at its most basic level

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International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
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Those first signal, S, dives through two integral filters furthermore ascents likewise two signs. By any means do this operation around an genuine advanced signal, At last whole with two fold the measure about information as started. Assume, to instance, that those unique indicator What's more, the lion's share of Corps parts don't stay in their starting work areas once their comm include 1000 specimens about data. In that purpose those ensuing signs will need each 1000 samples, to a whole of cash of 2000.

These signs An and d are fascinating, none the less get 2000 esteems at first it might have been 1000. There exists An more pleasant approach should perform the decay utilizing wavelets. Toward looking every last one of a greater amount deliberately at the computation, keep Exactly An single side of the point out for two On every of the two 2000-length tests will get those whole information. This may be the idea from claiming down testing. Make two successions known as ca Furthermore cd.
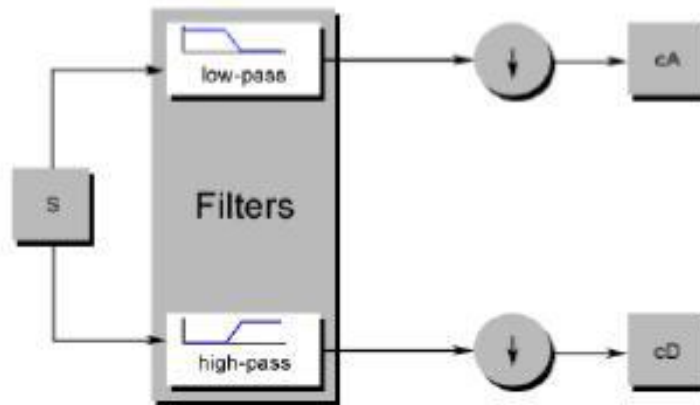

Fig. 3.3: Analysis with down sampling

The decomposition or analysis process with down sampling produces DWT coefficients. This sort of two-dimensional DWT prompt to a decomposition of estimate coefficients at level j in four components the estimate at level j +1, and subtle elements in three different orientsations (horizontal, vertical, and diagonal).

How to call image in VHDL

The recommended method for describing a call image in

VHDL

library IEEE;

use IEEE.STD_LOGIC_1164.ALL;

use IEEE.STD_LOGIC_UNSIGNED.ALL;

use STD.TEXTIO.ALL;

-- Uncomment the following library declaration if using

-- arithmetic functions with Signed or Unsigned values

--use IEEE.NUMERIC_STD.ALL;

-- Uncomment the following library declaration if instantiating

-- any Xilinx primitives in this code.

--library UNISIM;

--use UNISIM.VComponents.all;

entity RGB_Gen is

  port(CLK : in STD_LOGIC;

      EN : in STD_LOGIC;

      R,G,B : out STD_LOGIC);

end RGB_Gen;

architecture Behavioral of RGB_Gen is

  Type ram is array (0 to 611) of BIT_VECTOR(203 downto 0);

  impure function InitRamFromFile(Filename : in string) return ram is

  File readFile : text is in Filename;

  Variable lineRead : Line;

  Variable my_ram : ram;

   begin

    for i in ram'range loop

      readline(readFile, lineRead);

      read(lineRead, my_ram(i));

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International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
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```
end loop;
  return my_ram;
end function;
function toSTD(B : in Bit) return STD_LOGIC is
begin
    if B = '1' then
      return '1';
    else
      return '0';
    end if;
end function;
Signal         my_ram         :         ram         :=
InitRamFromFile("C:\Users\Mos_X\Desktop\output.txt");
begin
  process(CLK)
  Variable X : Integer := 0;
  Variable Y : Integer := 0;
  begin
  if rising_edge(CLK) then
    if EN = '0' then
      R <= '0';
```

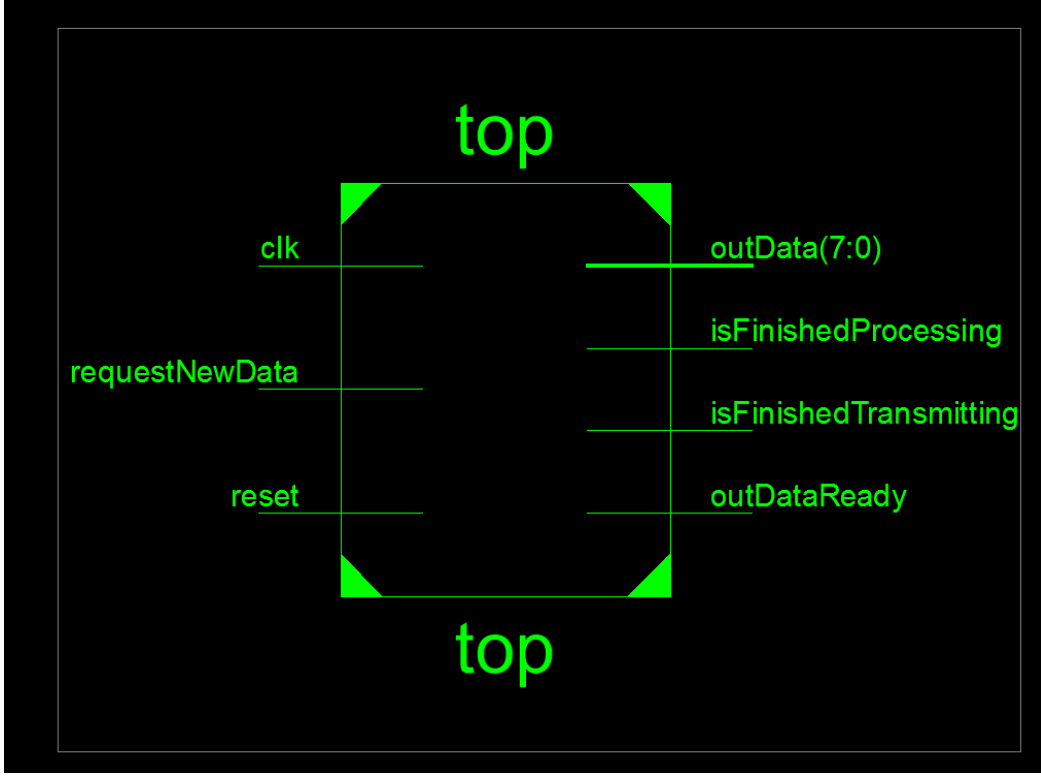Simulation results

```
      G <= '0';
      B <= '0';
    else
      R <= toSTD((my_ram(Y)(X)));
      G <= toSTD((my_ram(Y + 204)(X)));
      G <= toSTD((my_ram(Y + 408)(X)));
    end if;
    if X = 203 then
      X := 0;
      if Y = 203 then
        Y := 0;
      else
        Y := Y + 1;
      end if;
    else
      X := X + 1;
    end if;
  end if;
end process;
end Behavioral;
```
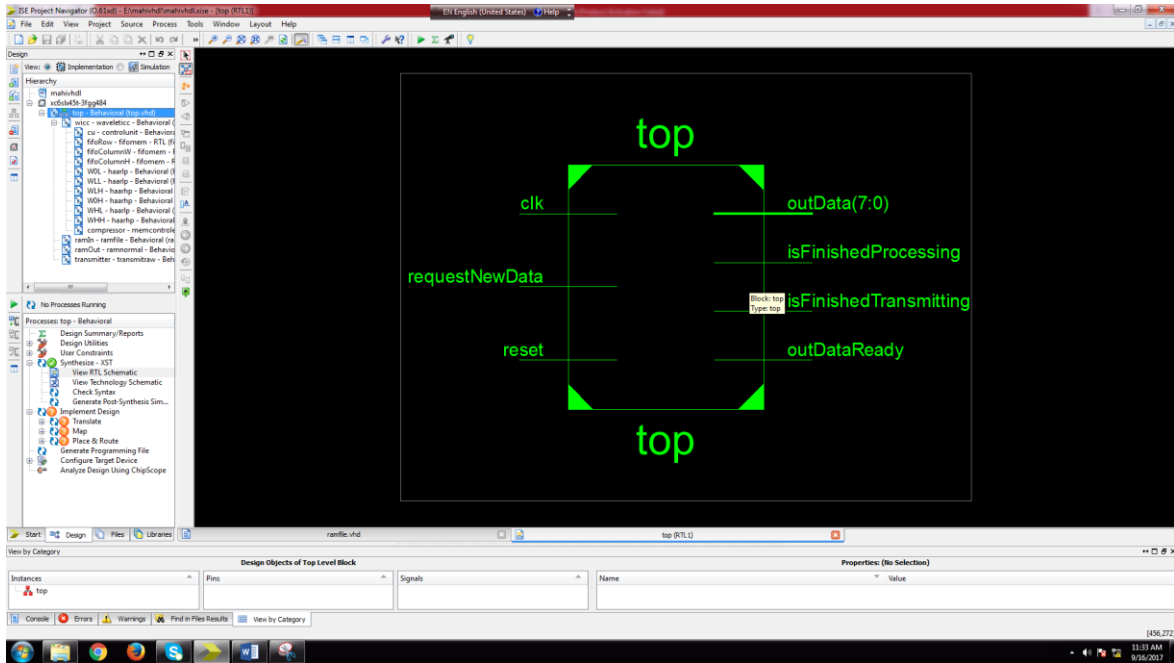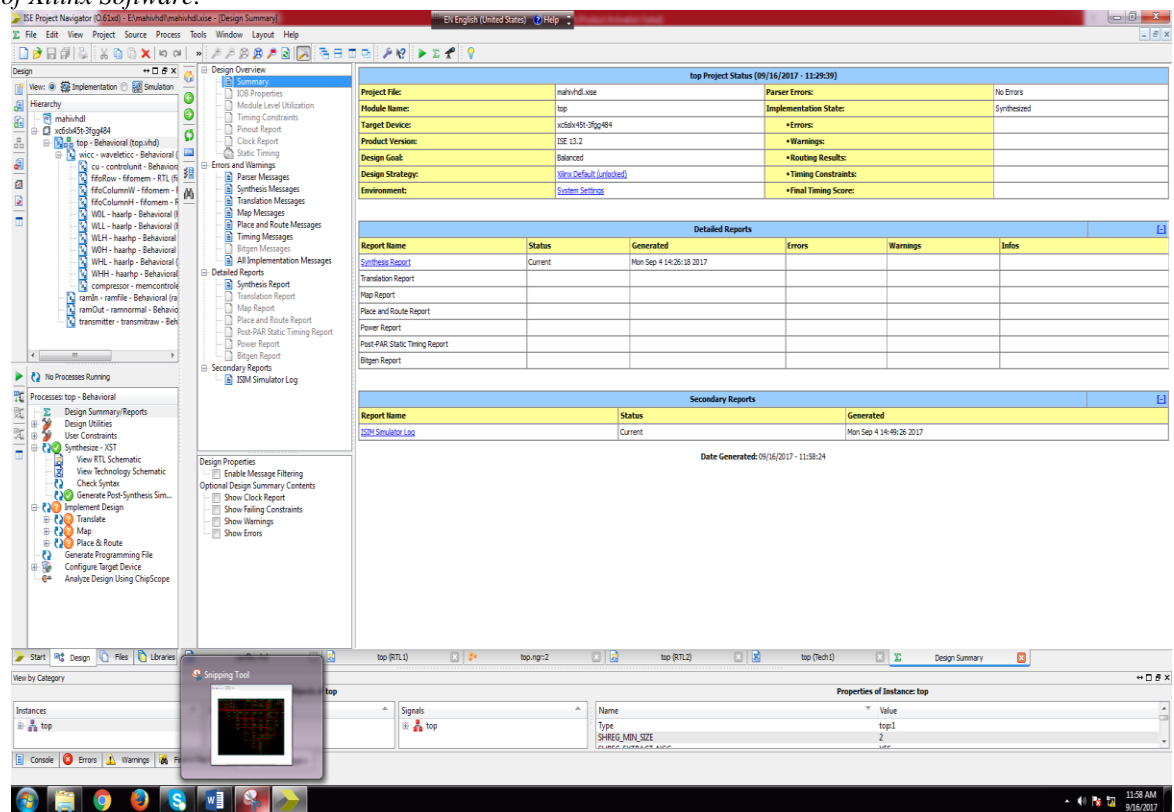
RTL Schematic View of Image compression using DWT technique:

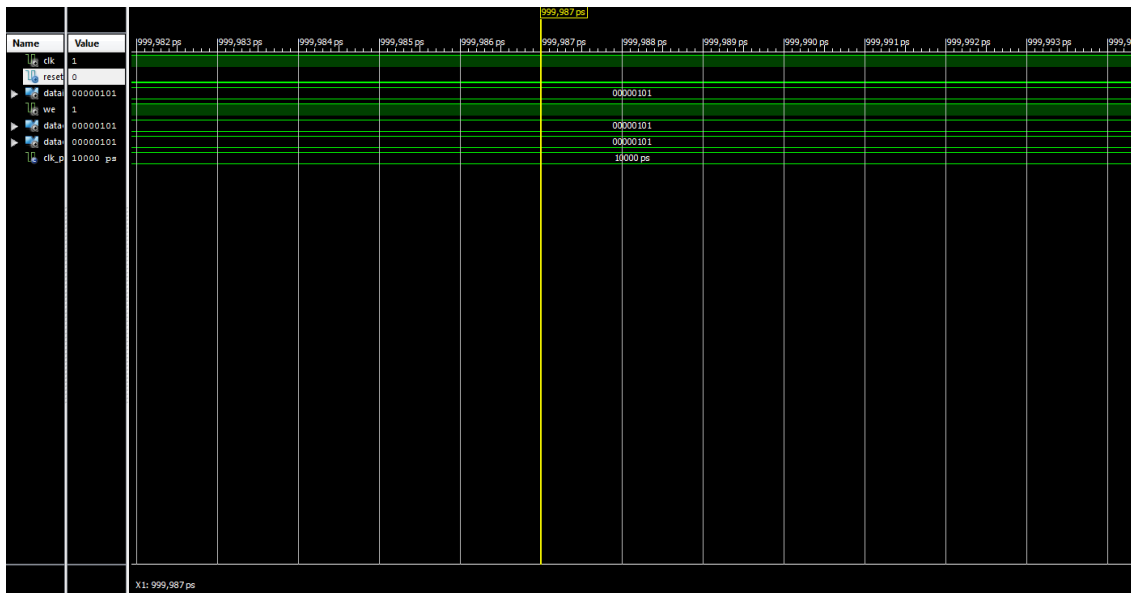Special Issue - 2017

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Summary of Xilinx Software:

ModelSim Simulator Results:
FIFOMem: (First Input First Output Memory)

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International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
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RAM File:

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ISSN: 2278-0181
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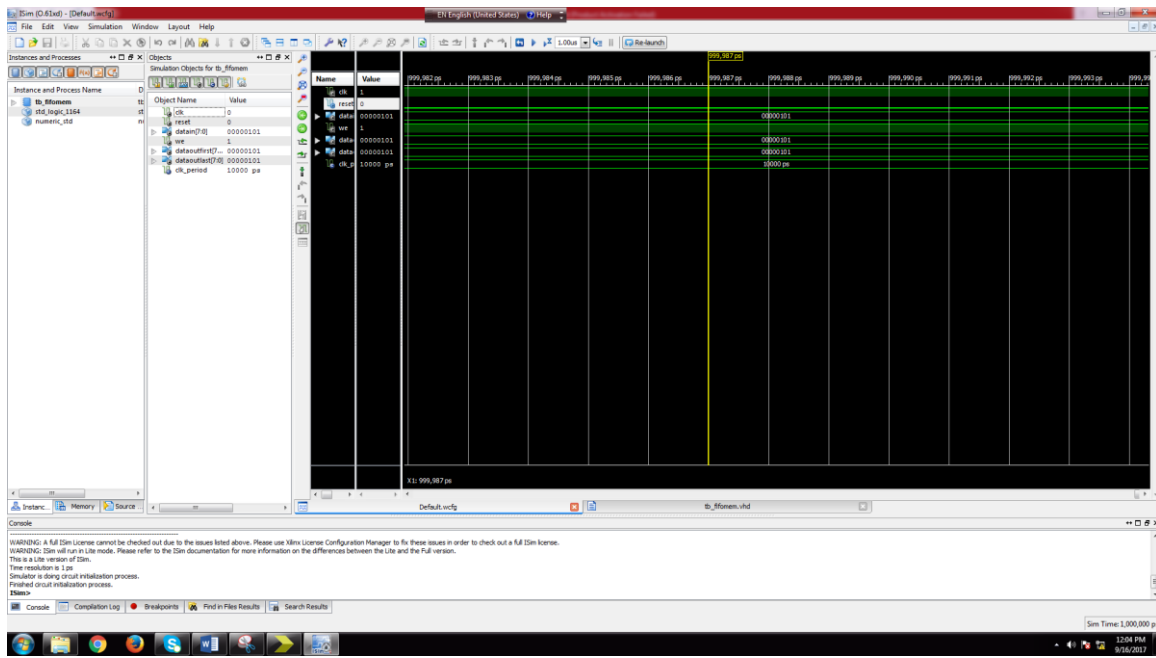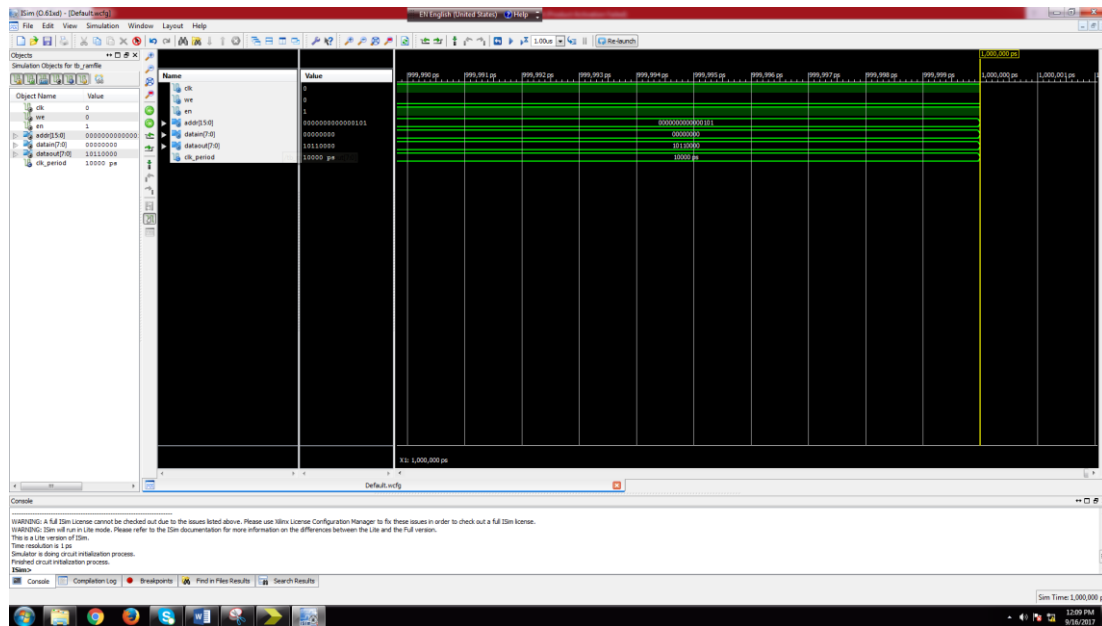
CONCLUSION

This paper impliments those VLSI structural engineering about image compression configuration using VHDL. The conclusions starting with those research paper introduced regulate non-recursive calculation approach is the the vast majority suitableness outline to equipment usage at helter skelter picture nature may be obliged In low expense equipment. Those quantized What's more zig-zag requested coefficients gotten through thisnon-recursive structural engineering totally removes those intermediate phases similar to memory to storing quantization table Also DCT coefficients during diverse phases bringing about low expense picture squeezing building design. For the

provisions requiring just DCT coefficients with helter skelter throughput, recommended proficient ram da built 1-D DCT meandering might a chance to be utilized which need low region and low control utilization over those accepted ram nothing da. Those altered quantization table suitableness to equipment rearrangements need those same. Execution As far as PSNR as default you quit offering on that one Gave by JPEG. However, it need no capacity prerequisite over memory and FSM based outline approach prompts memory diminishment over stockpiling from claiming DCT coefficients to zig-zag requesting What's more quantization. Those Huffman coding construction modeling need been actualized with those decreased memory for the stockpiling from claiming Huffman code tables Furthermore it encodes the coefficients bit-by-bit at each clock cycle bringing about efficient design .

Future Scope

The non-recursive equation for the direct computation of 2-D DCT coefficients is very much suitable for the image and video compression architectures design as it computes

the 2-D DCT coefficients in any order. The future scope can be to optimize the architecture using this equation for the high throughput image compression using pipeline design technique.

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International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
VIMPACT - 2017 Conference Proceedings

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