Grayscale Image Compression using Discrete Cosine Transform

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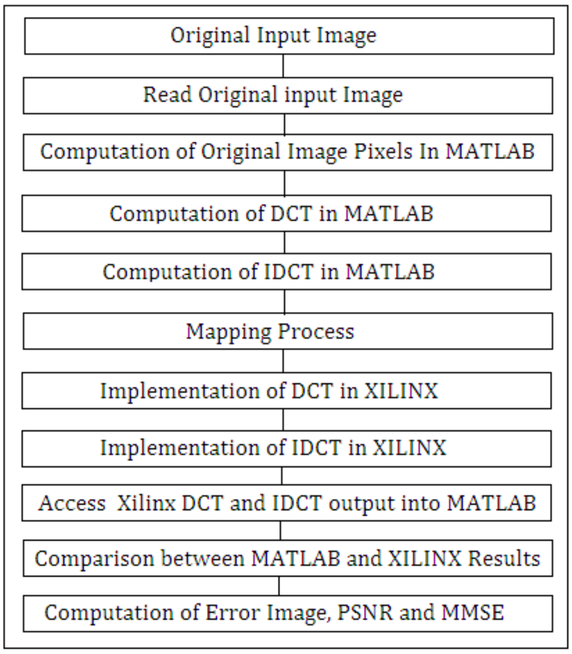
***Abstract* - Image compression is the reduction or elimination of redundancy in data representation in order to achieve reduction in storage and communication cost. [1] Discrete cosine transform (DCT) is computationally intensive algorithm it has lot of electronics application. DCT transforms the information time or space domain into frequency domain to provide compact representation, fast transmission and memory saving. [1]. DCT is very effective due to symmetry and simplicity. In this project we have used an intensive algorithmic flow for image compression, reconstruction of original image and error computation between original image and reconstructed image. This algorithmic flow used MATLAB-XILINX-MATLAB approach for mapping and loading process. For Grayscale image compression using DCT, initially selected 256*256 image and access or read this image for DCT computation, Then found that image pixels get reduced after DCT process, that means ultimately image get reduced. Similarly selection has modified for different images i.e. 64*64 and 8*8 images then got same compressed image after DCT image compression. After DCT computation here computed IDCT for reconstruction of image. Image reconstruction means whatever image pixels have compressed for a particular use need to decompress it also calculated, error image between original images and reconstructed image. In this project, the input image need to compress, that access/read into MATLAB and computed DCT and IDCT process over original image and calculated error between original image and reconstructed image. Similarly original image accessed into Xilinx through MATLAB using Mapping Process to implement DCT, IDCT and Error Image to compress and decompress a particular image. MATLAB is very much efficient and useful to take out each image pixels from original image also very helpful to load .txt file format from XILINX. The coding is simulated using XILINX 13.4 ISE and final error image shown through MATLAB 7.0.4.**

***Keywords*- Discrete Cosine Transform (DCT), Inverse Discrete Cosine Transform (IDCT), VERILOG Hardware Descriptive Language (VERILOG HDL), Very High Speed Integrated Circuit Hardware Descriptive Language (VHDL), Joint Photographic Expert Group (JPEG).**

I. INTRODUCTION

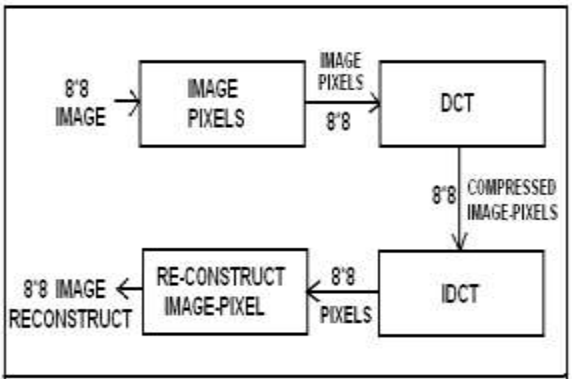
Grayscale image compression algorithms exhibit an increasing need for the efficient implementation to make modification as far as the future is concern. Because of latest technology up gradation and new technology demand for future, here focused on speed, area and power. By visualizing these concepts, here not only reduces area but also increases the efficiency of this project. In this project one of the most computationally intensive algorithms called Discrete Cosine Transform for grayscale image compression is implemented with the help MATLAB-XILINX-MATLAB approach. DCT consists of formula; this is computed into MATLAB and then computed image pixels in the form of matrix. So this processing is simple in MATLAB. But for Xilinx approach needs to generate algorithmic flow, as XILINX is not more familiar with image that means image cannot directly into XILINX. So while taking efficiencies into under consideration we have used MATLAB-XILINX-MATLAB approach. So that we can use MATLAB for image reading also for implementation we can use XILINX.

II. ALGORITHMIC FLOW



The algorithmic design flow gives us complete idea about project flow and this flow is useful to generate compression scheme. The design flow starts with the MATLAB environment for the computation of image pixels. First read one image into MATLAB as MATLAB is more suitable and efficient in case of image processing. There are different image formats ex. .jpeg, .png, .tif with different sizes as per image acquisition system.
As per project design flow, in this project have used MATLAB and XILINX both for image compression, ultimately used MATLAB-XILINX-MATLAB approach. Initially access/read original image into MATLAB for pixels computation so that we can able to apply these image pixels to Xilinx through Mapping Process between MATLAB and XILINX.

Block Diagram For Reconstruction Of Image In MATLAB Approach



BLOCK DIAGRAM FOR IMAGE RE-CONSTRUCTION USING DCT-IDCT

Fig. 2 is for block diagram for Image Reconstruction it consists of DCT and IDCT in MATLAB approach. For image compression any image format here we can use i.e. JPEG, PNG, TIF image format. For image compression the ultimate aim behind it is, reduces to memory required for transmission and storage.
As we have seen earlier that access input grayscale image and compute image pixels from MATLAB, then followed image compression using DCT as it is effective for image compression. After computation of image compression with the help of IDCT algorithm then here generated reconstructed image. So to understand whether compression process if properly doing or not to check this it applied on different images for DCT and IDCT also and reconstruct images. Along with this we will take certain comparison process also between input and output also it will decide our compression strength. There is certain algorithm and formula to generate DCT and IDCT of the image. In DCT algorithm it reduces the size of pixels as explain further.
A seen the block diagram of computation of DCT and IDCT, to compress an image there is a need that image we have to access first. Then first calculate pixel value . DCT is useful for image compression because DCT is discrete cosine transform matrix, there is certain algorithm to generate DCT matrix, that means for cosine transform need to generate cosine matrix and multiply this cosine matrix and also need to multiply transpose of cosine matrix, the formula of this cosine matrix as shown further. By using this matrix multiplication that means matrix multiplication we can go for DCT compressed image and whatever the image generated after DCT process it consists of reduced pixel size and that reduced pixel size we call it as a compressed image. But in

this case we have a question in mind that is it possible to generate compressed image which has very less pixel size, requires less area, reduced power so to verify it we will go for IDCT also we call it as

Formula For DCT:-

The N *N Cosine Matrix C = {C(u, v)} is defined as, C(u, v) =

$\sqrt{(1/N)}$ ---- $u = 0$, $0 \le v \le N-1$

$\sqrt{(2/N)}\cos[(2v+1)/2N]$ --- $0 \le v \le N-1$ $0 \le v \le N-1$

Then Finally we will get,

1. DCT = [C] * [Image] * [C']
2. IDCT = [C'] * [DCT] * [C]

where

- c is DCT process matrix generated after computation of formula.
- c' is the transpose of DCT process image matrix.

Computation MATLAB Result for 256*256 DCT Image Compression

MATLAB Result for 256*256 DCT Image Compression

MATLAB Workspace Result for DCT Image Compression

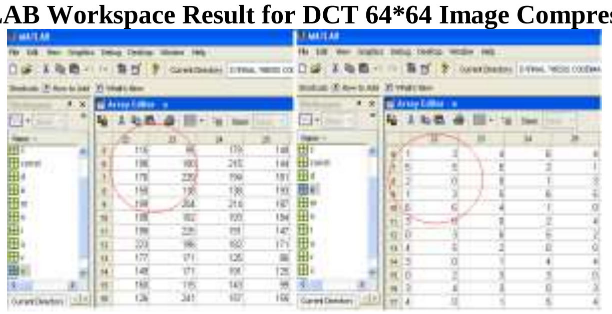
MATLAB Workspace Result for DCT Image Compression

As we see above output Figure3 and Figure4 i.e MATLAB Result for 256*256 DCT Image Compression and MATLAB Workspace Result for DCT Image Compression, it is clear to all that when apply DCT process to input image, then image pixels get reduced and image get compressed. So DCT efficiently worked on image compression. After for more confirmation applied another image also of different size i.e for 64*64 and 8*8. By this way it is sure about image compression process.

MATLAB Image Result for 64*64 DCT Image Compression:-

Figure 7 - MATLAB Image Result for 64*64 DCT Image Compression.

MATLAB Workspace Result for DCT 64*64 Image Compression:-



MATLAB Workspace Result for DCT 64*64 Image Compression.

Similarly figure5 for MATLAB Image Result for 64*64 DCT Image Compression and figure 6 for MATLAB Workspace Result for DCT 64*64 Image Compression. if applied 64*64 image and follow-up another DCT process to it then still we got compressed result for this image also. Finally decided to use 8*8 image.

MATLAB result for 8*8 DCT Image Compression:-

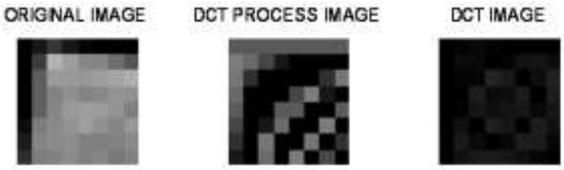


Figure 9, MATLAB result for 8*8 DCT Image Compression

Command Window Output for 8*8 image:-

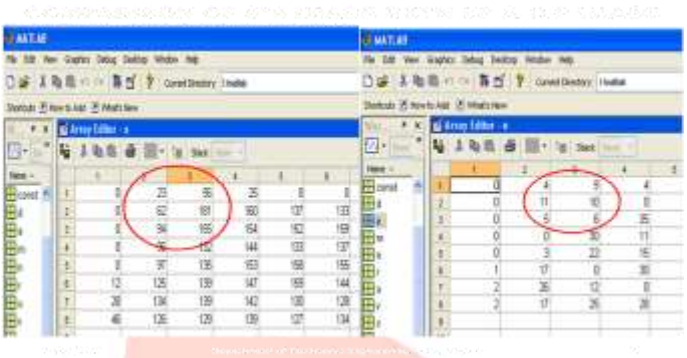
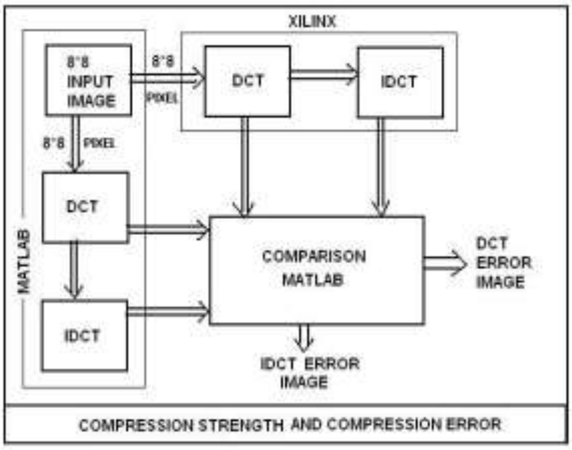


Figure 10, Command Window Output for 8*8 image.

In this project stepwise we have gone through different images i.e 256*256 image for DCT and IDCT and then for 64*64 image finally we have decided for 8*8 image then apply DCT process in MATLAB then finally it clears that pixel value get reduced and generate compressed image. So finally all works related to DCT for grayscale image compression of our project covered then also for more efficiency and depth so focused on XILINX approach also.

Block Diagram Form MATLAB–XILINX-MATLAB Comparison Approach For DCT Process:-

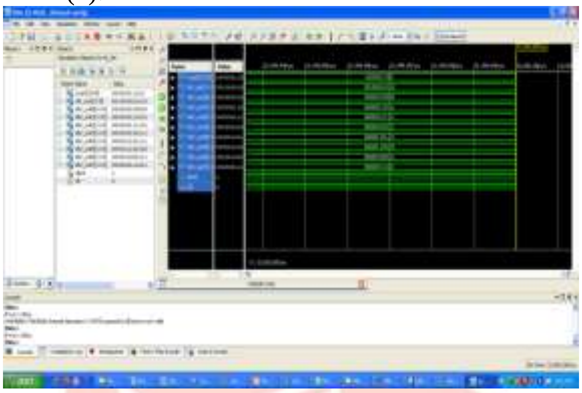


In this MATLAB–XILINX-MATLAB Comparison Approach for DCT and IDCT process, here initially, image is applied to MATLAB ,as that of previous one but here the processing is different than previous approach. In this approach, image applied to MATLAB. After reading image into MATLAB using syntax imread ('image.fomat');. Image just enter into the MATLAB and these image pixels visible at the command window and workspace. So after this it is possible to process on these pixels. In this MATLAB–XILINX-MATLAB Comparison Approach, initially whenever the image pixels, initially accessed into MATALB and these are stored in workspace. In this approach, there is a need of DCT computation to compress an image, so for this there is a need of DCT process matrix. For creation of DCT process matrix there is a need of computation of formula are as follows.
As shown in the formula for DCT, This formula need to compute in MATALB for DCT creation for that there is a need to follow DCT formula and equation-1 and just put that result into MATALB command window. Then after DCT computation there is a need to focus on IDCT i.e. there is a need to focus on decompression of compressed, that means ultimately need to reconstruction of image from the compressed image. These two DCT and IDCT results stored for comparison purpose.
Then after MATALB computation, here decided to go for implementation in XILINX. But for XILINX implementation requirement of input image pixels which is not directly accessible in XILINX. So for this there is necessity of follow communication techniques between MATLAB and XILINX. To reduce the complexity, this project followed only matrix

multiplication as explained in equation 1 and 2 then finally output results generated is DCT and IDCT of XILINX. These two results are stored in .txt files that are ‘output.txt’ and ‘output_iDCT.txt’ which consists of DCT and IDCT results from XILINX. Finally comparison followed between DCT / IDCT of MATLAB and XILINX. Finally generated result in image for i.e error image berween DCT nad IDCT of MATLAB and XILINX.
The result is followed because of three things

- MATLAB is more familiar and functional in case of image processing.
- XILINX has a advantage, it requires less are and power, with high speed because of HDL.
- Communication possible between MATLAB and XILINX.

Xilinx (Verilog Hdl) Implementation of DCT And IDCT:-
FOR IMAGE 1:-
By using Mapping Process, MATLAB and XILINX communication is possible. As shown above simulation result it is generated from XILINX which consists of IDCT results. This IDCT results is generated by Matrix Multiplication between input image and DCT process image. These two matrix taken from MATLAB by communication process between MATLAB and XILINX. The matrix multiplication is done by formula as
1. DCT = [C] * [Image] * [C’] -------- (1).
2. IDCT = [C’] * [DCT] * [C] -------- (2).

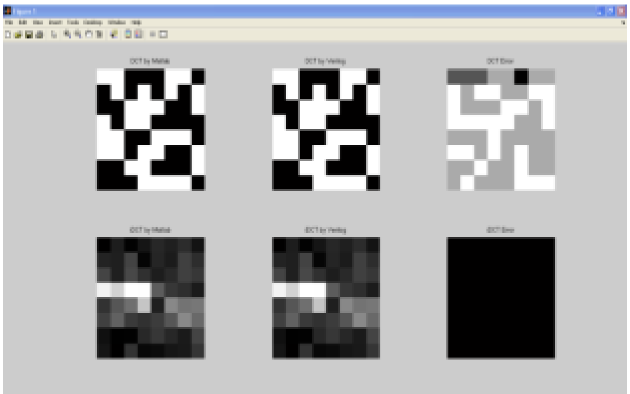


4.2.1. HDL SYNTHESIS REPORT

HDL synthesis report for XILINX Approach	
Components Required	Quantity
Macro Statistics RAMs	4
Multipliers	58
Adders/Subtractors	104
Registers	1600
Latches	8
Comparators	7
Multiplexers	39
Tristates	3072
Xors	1056

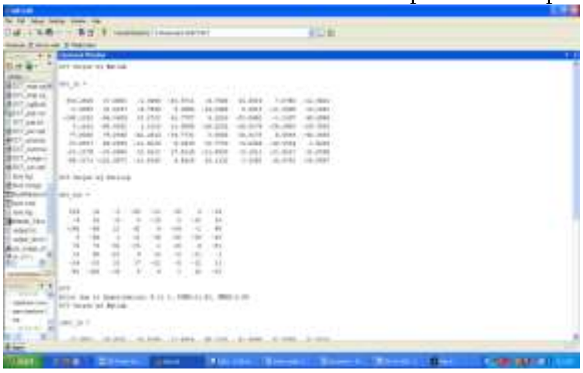
COMPARISON BETWEEN MATLAB DCT/IDCT AND XILINX DCT/IDCT FOR IMAGE 1

After matrix multiplication done in XILINX using VERILOG HDL, the DCT and IDCT output becomes stored into ‘output.txt’ and ‘output_iDCT.txt’ files respectively. Output from these files we have called/loaded into MATLAB. Whatever the output from MATLAB and XILINX in case of DCT and IDCT, finally comparison technique followed and it is found that there are error images generated by MATLAB.

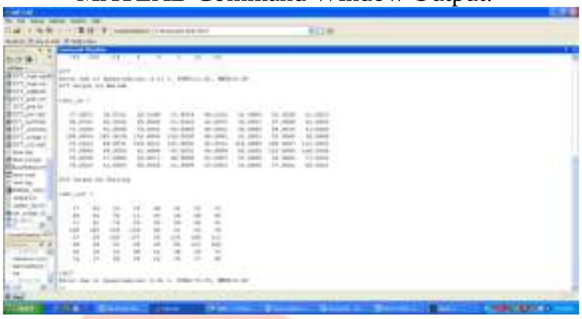


4.2.2. MATLAB COMMAND WINDOW OUTPUT

Result 1- From MATLAB Command Window Output For Comparison Process



MATLAB Command Window Output:-



MATLAB Command Window Output For Image 1:-

DCT Output by MATLAB

DCT_in =

536.2500 17.6803 -1.3994 -43.5731
-9.7500 41.6034 7.0740 -12.5926
-3.5855 41.5357 -8.7559 5.4580 -14.0499 6.6515 -11.6590 16.2443
-240.1252 -94.3409 23.2723 42.7757 4.1026 -53.8482 -1.3187 49.4598
5.1191 -85.6652 1.3136 21.5858 -18.0251 -18.0274 -38.2983 -29.7056
77.0000 74.2945 -42.1910 -34.7732 3.0000 28.6175 8.5464 -40.3956
23.0537 80.2954 -21.0220 9.0410 36.7736 -5.0628 -10.1564 1.8418
-23.1178 -32.2886 32.4313 17.8118 -21.4530 -5.1611 -11.0223 12.0388
-80.3171 -101.6873 -13.0140 4.8415 10.1130 3.3683 10.4752 -34.5587

1. DCT Output by VERILOG

DCT_out =

534	16	-3	-45	-11	39	6	-14
-4	41	-9	5	-15	6	-12	16
-240	-95	22	42	4	-54	-2	49
5	-86	1	22	-18	-19	-39	-30
76	73	-43	-35	2	28	8	-41
23	80	-22	9	36	-5	-11	1
-24	-33	32	17	-22	-5	-12	11
-81	-102	-14	4	9	3	10	-35

2. DCT
- Error due to Quantization: 8.11 %,
- PSNR:21.82,
- MMSE:0.08

3. IDCT Output by MATLAB:-

iDCT_in =

17.0872	39.9762	19.0189	33.9934	48.0102	41.9990	52.0059	32.0026
44.9762	42.0065	69.9949	21.0018	46.9972	39.0003	67.9984	52.9993

71.0189	41.9949	74.0041	54.9986	40.0022	49.9998	68.0013	61.0006
208.9934	183.0018	218.9986	218.0005	89.9992	61.0001	53.9995	38.9998
57.0102	84.9972	105.0022	172.9992	42.0012	124.9999	108.0007	111.0003
67.9990	94.0003	62.9998	56.0001	64.9999	85.0000	125.9999	100.0000
30.0059	17.9984	19.0013	48.9995	61.0007	47.9999	38.0004	71.0002
34.0026	16.9993	58.0006	23.9998	26.0003	35.0000	37.0002	59.0001

4. IDCT Output by VERILOG

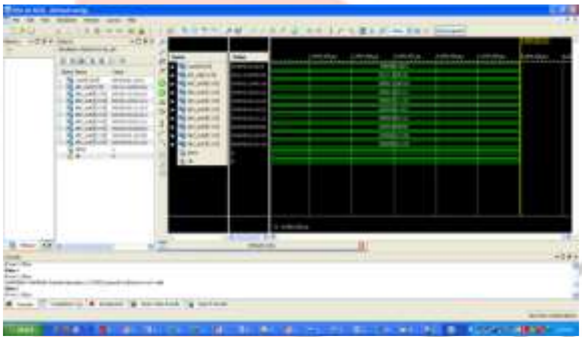
iDCT_out =

17	40	19	34	48	42	52	32
45	42	70	21	47	39	68	53
71	42	74	55	40	50	68	61
209	183	219	218	90	61	54	39
57	85	105	173	42	125	108	111
68	94	63	56	65	85	126	100
30	18	19	49	61	48	38	71
34	17	58	24	26	35	37	59

5. IDCT

- Error due to Quantization: 0.02 %.
- PSNR:76.35.
- MMSE:0.00.

XIILINX IMPLEMENTATION FOR DCT AND IDCT:-
FOR IMAGE 2:-



COMPARISONOF IMAGE BETWEEN MATLAB DCT/IDCT AND XILINX DCT/IDCT FOR IMAGE 2:-

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