Design and implementation a prototype system for fusion image by using SWT-PCA algorithm with FPGA technique

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Article Info

ABSTRACT

The technology of fusion image is dominance strongly over domain research for recent years, the techniques of fusion have various applications in real time used and proposed such as purpose of military and remote sensing etc., the fusion image is very efficient in processing of digital image. Single image produced from two images or more information of relevant combining process results from multi sensor fusion image. FPGA is the best implementation types of most technology enabling wide spread.This device works with modern versions for different critical characteristics same huge number of elements logic in order to permit complex algorithm implemented. In this paper,filters are designed and implemented in FPGA utilized for disease specified detection from images CT/MRI scanned where the samples are taken for human's brain with various medical images and the processing of fusion employed by using technique Stationary Wavelet Transform and Principal Component Analysis (SWT-PCA). Accuracy image output increases when implemented this technique and that was done by sampling down eliminating where effects blurring and artifacts doesn't influenced. The algorithm of SWT-PCA parameters quality measurements like NCC, MSE, PSNR, coefficients and Eigen values.The advantages significant of this system that provide real time, time rapid to market and portability beside the change parametric continuing in the DWT transform. The designed and simulation of module proposed system has been done by using MATLAB simulink and blocks generator system, Xilinx synthesized with synthesis tool (XST) and implemented in XilinxSpartan 6-SP605 device.

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1. INTRODUCTION

Several domains ways of acquired information extracting are refered to fusion term where fusion image integrating method of information relevant by images set.Fused image resultant is treated as a single image which is suitable and high informative for processing or perception visual for separately considered more than any original images input [1, 2]. The methods of fusion image comprise the integration of different sources information which result high informative fused image. Image fusion is divided mainly into various levels where in this article used fusion of pixel-level, image fusion of pixel-level technique has different methods as Stationary Wavelet Transform (SWT), Discrete Wavelet Transform (DWT), Discrete Cosine Transform (DCT), Principal Component Analysis (PCA) and average weighted. SWT method is important

method technique for fusion image because of it is feature excellent and analysis frequency [3-5]. The stationary wavelet transformation is more active performance in transformation image compared with discrete counterpart with its lossless reported, the main reason isin step down sampling of DWT and that guide process information to discards. Because the step down sampling does not happen in SDWT so after decomposition the approximation coefficients has the same length of original input signal and that is why using SWT method in this articles [6-8].

Much of the research has been performed for the purpose of developing image quality but still suffer from some problems such as principle uncertainty Heisenberg, shift-invariance lack, effects of blurring, artifacts and noise. To addition, any image is unclear because it has a foggy and special contrast intensity and so it will need low and high pass filters with many cut off frequencies, which increases the complexity of the circuit more and the size of the model used. Various previous works in this field, in [9] investigate that pyramid laplacian and method related transform wavelet using fusion image, the results explain that in both cases Peak Signal to Noise Ratio (PSNR) increase and decrease mean square error (MSE) but it has low edges and boundary values. In [10] represents that image obtained by various formal accord fusion image, where decomposed input image through stratifying 2D-DWT based algorithm fusion laplacian for lower approximation and for higher level algorithm fusion wavelet using for combined SF. The results explain that by advocate fusion obtained image with high quality however widely decomposition of various resolution are not invariant translation due to process sampling is down for underlying. In [11] pyramid laplacian adopted so that it isdepending on pixel level and images of multi focused using to obtained individual image same of Android stratify but it uses inverse filtering which will leads to change local color. In [9] investigate transform wavelet method using fusion image by criteria smoothness and gradient combination the results show that fusion obtained by this method is better than all the other types compared of wavelet transform but it needs very large circuit processing so it will make extra power dissipated.

In this paper using FPGA programmed by SWT-PCA algorithm because it provides various platforms computing such as pipelining , concurrency and reconfigure ability. The majority reason for that is FPGA includes the main processor that provides multi benefits over the other DSPs circuits such as low cost, low dissipated power(heat) usually under 1 watt so it can use battery as a power supply [12]. Also FPGA architecture flexibility gives prospect making electronic system exceedingly consolidated beside that because it's architecture is flexible and programmability, allows to change huge amount of logic glue peripherals and extrinsic components that is required by processor formed systems. The use of FPGA will reduce the size of the circuit and increase its efficiency to handle a huge number of images and the extent of frequencies is very wide by changing the cut off frequency through the programming of FPGA by VHDL which commensurate with any algorithm and thus provides more flexibility of the circuit [13-15]. Fusion rule of SWT for Xilinx System Generator is used in MATLAB by algorithm implementation in this paper, then code HDL is generated by system generator finally implementation hardware modeled on FPGA Xilinx Spartan 6-SP605 with SWT-PCA algorithm applied.

2. FUSION IMAGE TECHNIQUES

The techniques of fusion image are divided into two domains frequency (spectral) and time (spatial). PCA transform variables correlated number into variables uncorrelated,so that,to become more reliable and accurate. Further that dimensions number are reduced by selecting Eigenvector value of high order as component principle for high rate computation results. It is method of rigorous quantitatively that new group of variables is generated called essential components where most of these components are perpendicular to each other which guide to alleviate information redundant. PCA has widely applications such as matching pattern, wireless communication, machine learning and image processing.

When output image quality poor due to effects blurring [16-18], artifacts and distortionresults from shift-invariance lack because of DWT down sampling. Resolving these issues are done by down sampling removing using SWT so, conserve output imagewith high informative and quality. Decomposed original image into approximation vertical and horizontal by applying high pass and low pass filters wise row and wise column. Figure 1 elaborates detail of diagonal, horizontal, vertical and approximate result from wise column and wise row decomposed by same filtration. High and low pass filters conserve high and low frequencies beside information detailed provides at respective frequencies [19-21]. The following are SWT equationsof decomposition wavelet,

$$R_i, s_1, s_2 = \sum_{m1} \sum_{m2} p_0^{\uparrow 2i} (m_1 - 2s_1) p_0^{\uparrow 2i} (m_2 - 2s_2) R_{i-1}, m_1, m_2 \tag{1}$$

$$W_i^1, s_1, s_2 = \sum_{m1} \sum_{m2} p_0^{\uparrow 2i} (m_1 - 2s_1) f_0^{\uparrow 2i} (m_2 - 2s_2) R_{i-1}, m_1, m_2 \tag{2}$$

$$W_i^2, s_1, s_2 = \sum_{m1} \sum_{m2} f_0^{\uparrow 2i}(m_1 - 2s_1)\, p_0^{\uparrow 2i}(m_2 - 2s_2) R_{i-1}, m_1, m_2 \tag{3}$$

$$W_i^3, s_1, s_2 = \sum_{m1} \sum_{m2} f_0^{\uparrow 2i}(m_1 - 2s_1)\, f_0^{\uparrow 2i}(m_2 - 2s_2) R_{i-1}, m_1, m_2 \tag{4}$$

Where W_i^3, s_1, s_2; W_i^2, s_1, s_2; W_i^1, s_1, s_2 and R_i, s_1, s_2 are components diagonal (HH), high frequency for Vertical (HL), high frequency for horizontal (LH) and low frequency (LL) for SWT respectively. i = 0,1,2,…..i-1 is level decomposition with $p_0^{\uparrow 2i}$ and $f_0^{\uparrow 2i}$ are added zeros indicated by 2i-1.
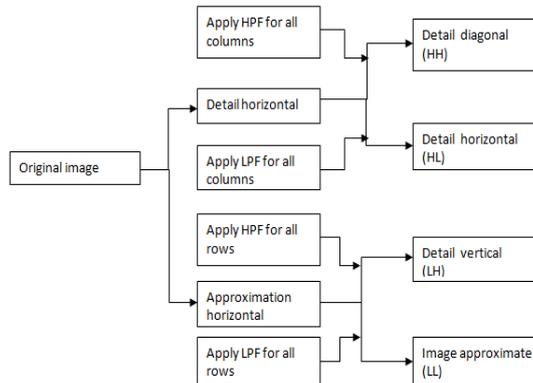
Figure 1. The explaination diagram for processing of decomposition image that using SWT method

The reconstructed SWT is shown in (5):

$$\begin{aligned}
R_{i-1}, m_1, m_2 = \tfrac{1}{4}\sum_{j=0}^{3}(\sum_{s1}\sum_{s2} p_1(m_1 - 2s_1 - j)p_1(m_2 - 2s_2 - j)R_i, s_1, s_2 \;+ \\
\sum_{s1}\sum_{s2} p_1(m_1 - 2s_1 - j)f_1(m_2 - 2s_2 - j)w_i^1, s_1, s_2 \;+ \\
\sum_{s1}\sum_{s2} f_1(m_1 - 2s_1 - j)p_1(m_2 - 2s_2 - j)w_i^1, s_1, s_2 \;+ \\
\sum_{s1}\sum_{s2} f_1(m_1 - 2s_1 - j)f_1(m_2 - 2s_2 - j)w_i^2, s_1, s_2)
\end{aligned} \tag{5}$$

When average and median filtersare combined to give performance better for reduction noise and resizes, adaptively the mask filter is depending on mask noise level. The noise is reduced by this technique and detail image will be better by conserve edges.In part of reduction noise, each pixel check sequentially, if the average value is less than the pixel value that is means noise affected on pixel and mask median value replace the pixel otherwise pixel value unchanged. The eigen values can be calculated by the following equation:

$$\mathrm{Det}|R_i - \gamma I| = 0 \tag{6}$$

Where γ is the Eigen values.To calculate the co-ordinates that have component principal direction for all data points by (7):

$$DV_i = r_{j1}B_1 + r_{j2}B_2 \dots\dots\dots r_{jm}B_m \tag{7}$$

Where r_j is factor for j coefficient, DV_i is ith component principal and B_1, B_2…………B_m are each data co-ordinate [22-24].

2.1. SWT-PCA algorithm proposed
The proposed method has two steps: at stage preprocessing, filter average and median combined enforce on input images then SWT-PCA hybrid is using for fusion image. The steps below explain stage of preprocessing.
Step 1: mask resize adaptively:
Filter initialize by m=3.
Evaluate $R_1 = MED - MIN, R_2 = MED - MAX$
Check if $R_1 > 0$ and $R_2 < 0$ then go to step1 otherwise the mask size enlarge by m=m+2.

Where m, R_1, MAX, MIN and MED represent size of the mask, average value, maximum, minimum and median respectively.

Step 2: The values median are evaluated by using filtering median.

The output images K1 and K2 are gained when input images enforce by additional filters SWT-PCA hybrid, K1 and K2 images are used to sub bands decomposed HH1, HL1, LH1, LL1 and HH2, HL2, LH2, LL2. The maximum values of Eigen vectors and sub band are calculated by using PCA. Sub bands are mentioned and combined to sum and multiply each images sub bands. The following equations represent the calculation of new subbands as HH$_{new}$, HL$_{new}$, LH$_{new}$, LL$_{new}$ [25-27]:

$$LL_{new} = DV_1 \times LL_1 + DV_2 \times LL_2 \tag{8}$$

$$LH_{new} = DV_3 \times LH_1 + DV_4 \times LH_2 \tag{9}$$

$$HL_{new} = DV_5 \times HL_1 + DV_6 \times HL_2 \tag{10}$$

$$HH_{new} = DV_7 \times HH_1 + DV_8 \times HH_2 \tag{11}$$

Where DV_1, $DV_2 ... ... DV_8$ are sub bands components principal.

The algorithm of hybrid SWT-PCA involved in Figure 2 where the average and median filters combined are enforced to input images where the filter output is loaded to wise row and wise column of high and low pass filters which are designed, simulated and implemented in FPGA. SWT Haar applying to obtained sub bands by decomposedthem. PCA is usedfor evaluation resultant coefficients and each image source coefficient enforce to denoted PCA coefficients, components PCA merges fusion rule to new coefficients decomposed (HHnew, HLnew, LHnew and LLnew). The transform of combined coefficients is loaded to inverse SWT in order to obtain image fusion.Finally, fusion image that is processing in FPGA and MATLAB with high informative and quality display on computer. Most of the algorithm in SWT-PCA was implemented in Field Programmed Gates Array (FPGA) Xilinx Spartan6-SP605 deviseto gain high accuracy and speed in data processing also in order to save power and using small size of the proposed electronic circuit.
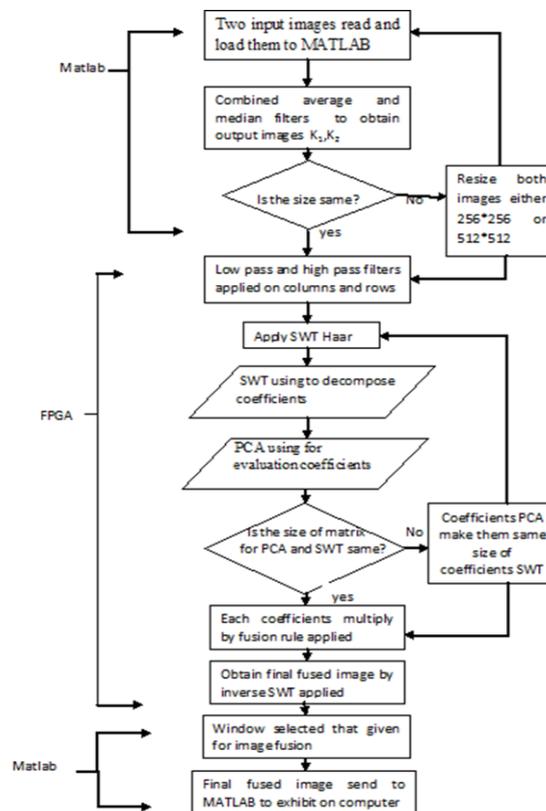

Figure 2. Flow chart of the proposed method

3.   FPGA IMPLEMENTATION HARDWARE

The algorithms of fusion image processing and implementation on hardware are considered as the most achievable method for systems performance improving. FPGA hardware reconfigurable features is superior offering compare with DSP and other devices hardware because of reliability product and advantages maintainability in processing of digital image. Many algorithms require sets of multiple data processing that sequentially performed in FPGA and on computer [14]. The approximate information and details of the image decomposed by using low pass and high pass filter respectively, this scheme of extrapolation turns into very simple when implemented in hardware. High pass and low pass filters designed and implemented in Xilinx System Generator as shown in Figure 3. The process of decomposition can be repeated with approximations successive where many components with less resolution existence are decomposed.
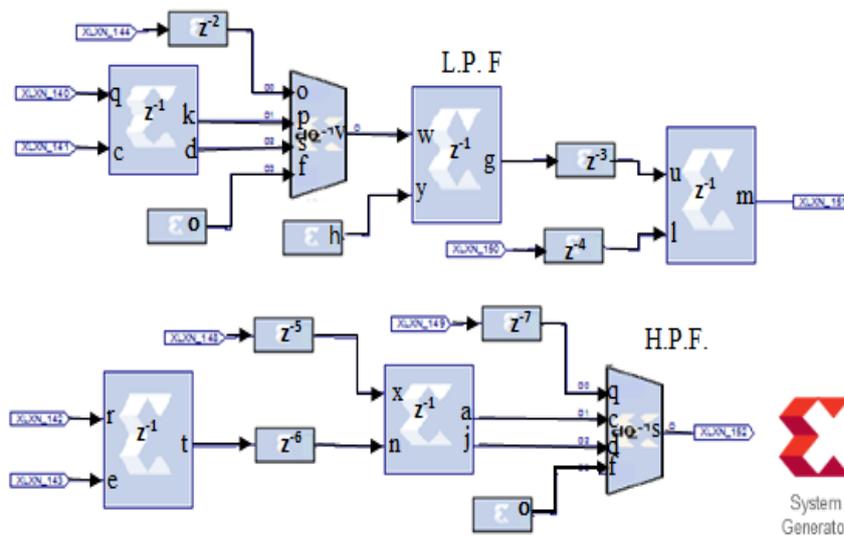
Figure 3. High pass and low pass filters design and implemented in FPGA Xilinx system generator

Schematic diagram of based on algorithm of fusion image is shown in Figure 4, module design in simulnk completed for fusion image that implemented on FPGA Xilinx Spartan6-SP605 device and using SWT-PCA algorithm are shown in Figure 5. The images store in block input buffer after that send for processing into block of fusion that information receives of wise pixel and using BRAM to store them. Each pixel is red by RAM dual port additional that all pixels display through connector output, the file programming using VHDL that can be created by Xilinx ISE. System generator simulation is using to generate block for co-simulation hardware model that has been performed by JTAG.
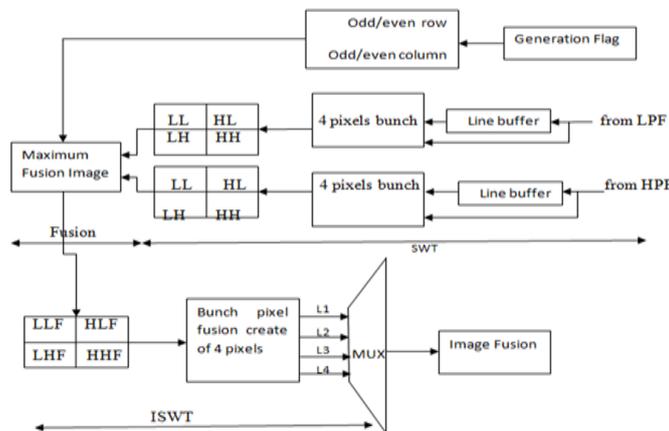

Figure 4. Block diagram of SWT-PCA algorithm for fusion image

These modules synthesis by files net list creationpriorwhich represent module implementation input. The next stage of files generation is that design logic transform to a bit file and using FPGA for downloaded. The system model in Figure 5 details as below:

Step 1 : From file of images load sample 1 and sample 2 imagesbefore transform into scale of gray by using MATLAB then transform to matrix format.

Step 2 : Combine average and median filters to obtain output images K1 and K2 and resize both images to be 512*512 or 256*256.

Step 3 : Apply low pass and high pass filters to each column and row.

Step 4 : The proposed model simulink of SWT rule maximum fusion based on SWT-PCA algorithm is improved in MATLAB and FPGA Xilinx Spartan6-SP605.

Step 5 : Xilinx System Generator (XSG) is inserted and using for coding VHDL compileand bit filecreation then send it to FPGA.

Step 6 : SRAM is using to store FPGA output then using MATLAB for postprocessing.

Step 7 : SRAM output is loaded to MATLAB in order to image fusion output analysis.
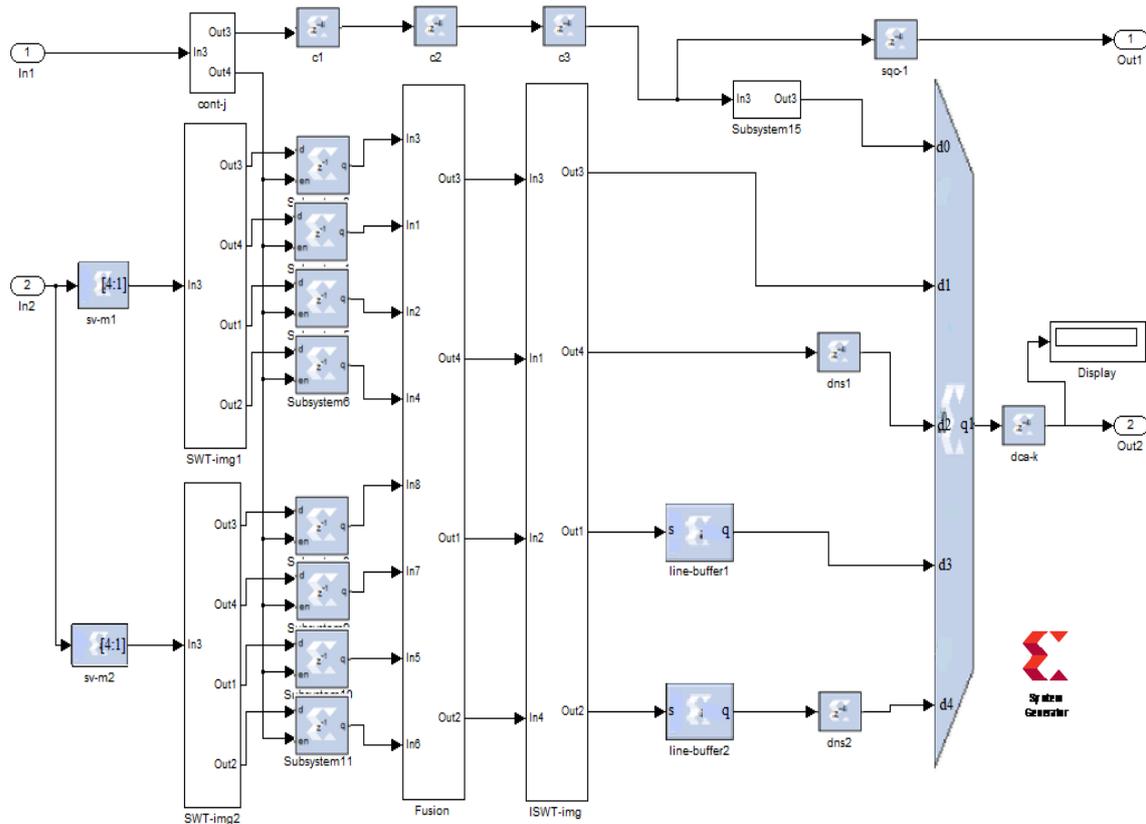
Figure 5. Modeling simulink of fusion image using SWT-PCA algorithm applied in FPGA

SWT-image block internal design is shown in Figure 6 contains of two stages, in first stage of SWT with one level, all image rows transform again utilize horizontally filter bank take in consideration decomposition of first level produces images sub-sampled and several number of 4 filtered. In decomposition of second level, further SWT sub bands of lowest divided using same above method of filtering, sub band lowest further decomposed to 4 sub bands where each row and columns of sub band lowest send to fusion block.
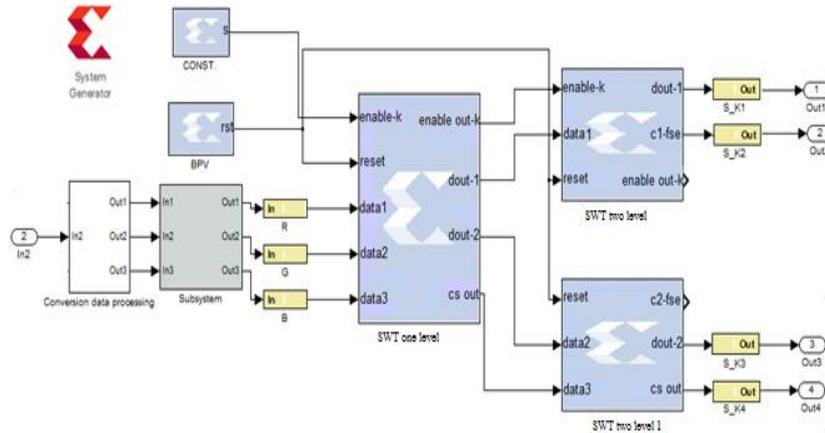
Figure 6. Internal design of SWT-img block that using in Figure 5 for system proposed model

4. RESULTS AND DISCUSSION

The Boolean expression optimization in FPGA is taken in consideration speed and area of processing here optimization of delay and area occurred by implementation of SWT-PCA algorithm where segments wire of FPGA programmable are routing through blocks FPGA among connection established. The utilization device contains the following: utilization and distribution logic, Figure 7 represents report synthesis the proposed system which is implemented in FPGA.
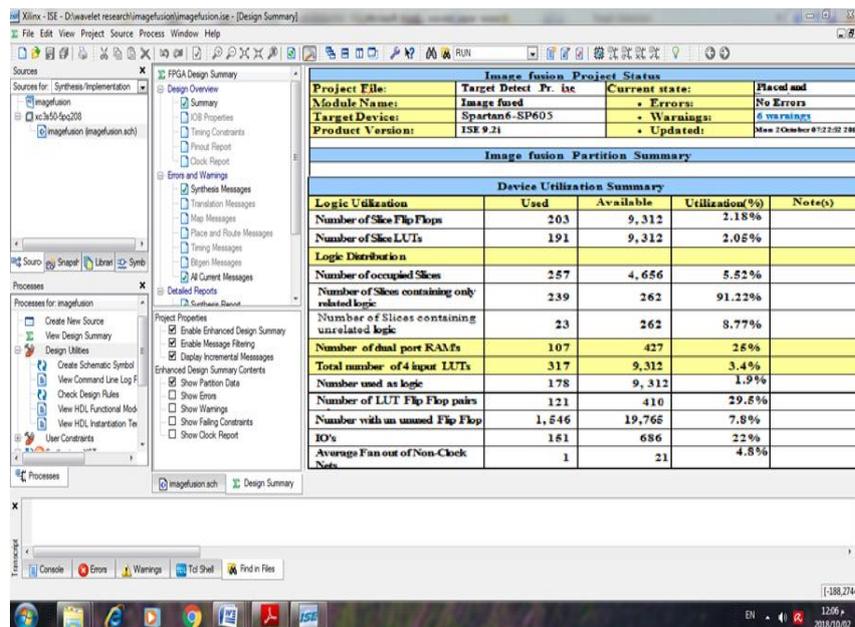
Figure 7. Synthesis report of system proposed implemented on FPGA

The functionality of SWT is verified and simulated by their development that is done when the model RTL is sent to the process of synthesis using tool ISE of Xilinx as shown in Figure 8. In process of synthesis converted model RTL to the mapped net list level gate then to library of technology, the results and synthesis of SWT design have been analyzed. The results of simulation models in the proposed design are presented in the diagram of Figure 9 where MATLAB using input VHDL for processing actually the file of input image. The LL-coefficients contain image compressed that was gotten when applied SWT while the reverse applied by using decompressing method. Where the file input is represented by image compressed and VHDL using for doing ISWT.
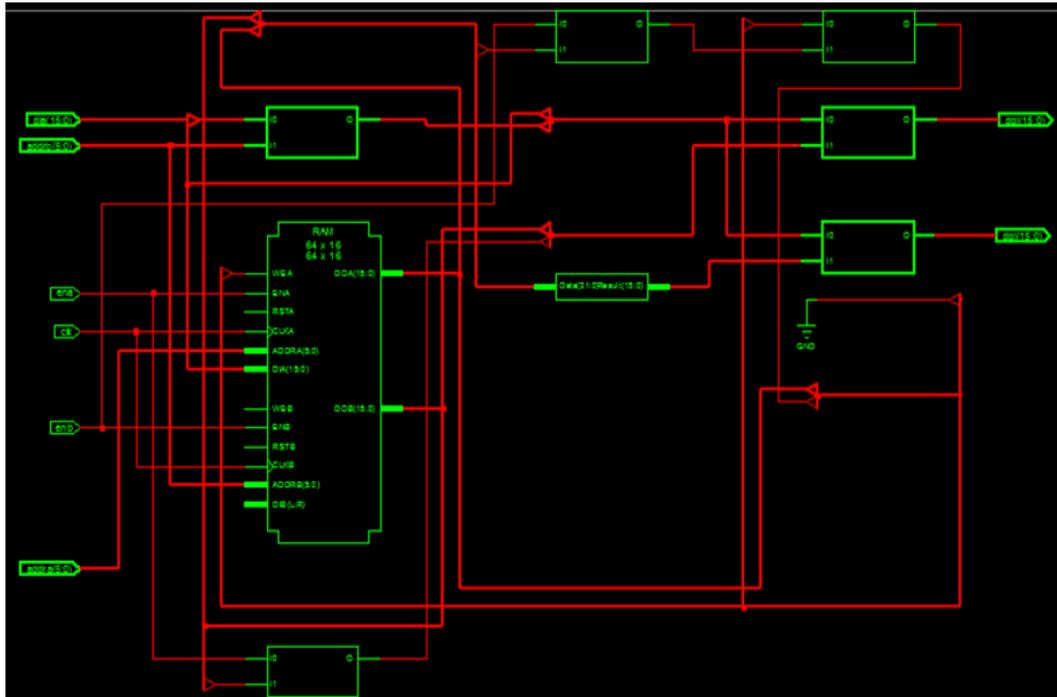
Figure 8. RTL schematic diagram in Xilinx FPGA system design

Xilinx platform is including code VHDL that using for the simulation waveform of coefficient extracted as shown in Figure 9. The calculation of coefficients have been done before and after fused image by using SWT-PCA method. The contrast is improved and high visibility provides by fused image, samples image individually of information integrated. The processing and diagnosis accurate can be done for injuries, tumour and cancer with high resolution and contrast by using fusedimage. The images fusing technique used the algorithm of SWT-PCA for different processing stages and these images Eigen values and coefficients are denoted as advance case.
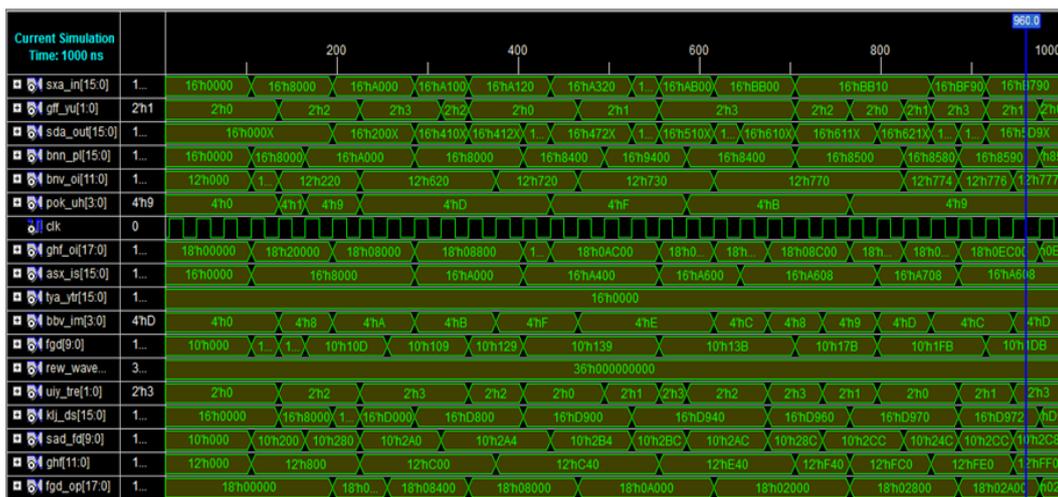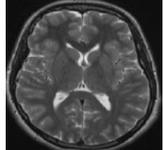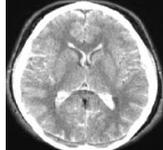

Figure 9. Simulation waveform of propoed system that implemented in FPGA

Database images that using in Table 1 for analysis are taken different images for several patients, these images using for fusion further calculated Eigen values and coefficients as shown in Table 1. SWT-PCA using for adopting the method of fusion image, the Eigen values and coefficients are listed in Table 1.

Table 1. Different medical images with their Eigen values and coefficients of fused one

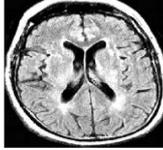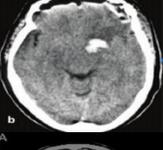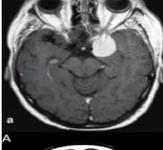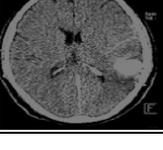| Sl.no.	Ref.[11] Image sample1 CT scan	This work Image sample2 MRI	Fused image	Coefficient	Eigen value	Coefficient	Eigen value
1.				0.5892 - 0.8183 - 0.8183 - 0.5892	0.3203 7.839	0.5923 - 0.8102 -0.8102 -0.5923	0.4651 8.7331
2.				-0.9532 0.2357 0.2357 0.9532	0.6358 5.7663	-0.8853 0.3177 0.3177 1.1153	0.7531 5.9447
3.				-0.7947 0.7654 0.7654 0.7947	1.2777 5.0938	-0.7092 0.8332 0.8332 0.8092	1.8232 5.4377
4.				- 0.8367 0.5105 0.5105 0.8367	0.7731 5.7352	-0.8244 0.6211 0.6211 0.8544	0.8127 5.9164
5.				0.5414 - 0.8712 - 0.8712 - 0.5414	0.3601 7.3421	0.5721 -0.8687 -0.8687 -0.5721	0.4722 7.8347
6.				-0.9115 0.2844 0.2844 0.9115	0.6167 5.3125	-0.8902 0.3102 0.3102 0.8902	0.6678 5.7551
7.				-0.7149 0.7981 0.7981 0.7149	1.1057 5.1443	-0.6922 0.8203 0.8203 0.6922	1.3655 5.7342
8.				- 0.8233 0.4443 0.4443 0.8233	0.6121 5.6854	-0.8115 0.6281 0.6281 0.8115	0.6733 5.8402
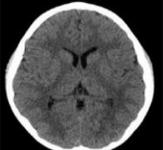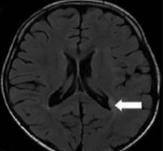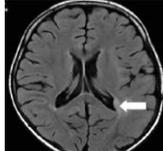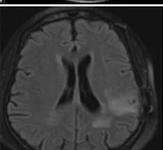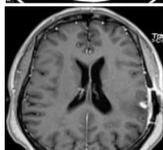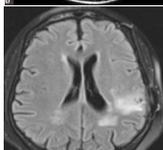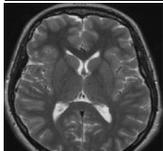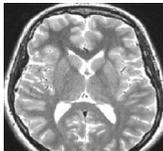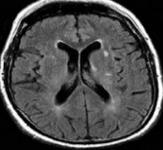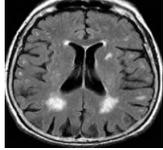
5. CONCLUSION

Image fusion tempts a lot of attention specialist in the vision of computer and sensing of remote fields while in various domains of applications the processing real time tackle presented also in implementations of hardware. SWT-PCA technique is applied here for better resolution and contrast of image fusion additional that images corners are detected using Edge detection, image fusion is the best way to diagnose and treat diseases, especially in the early stages. Images samples are taken and processing using SWT-PCA algorithm to reinforce the image with better contrast. Employed fusion image is taken in order to obtain information mutual and common using information better equality for each image, also contrast and resolution better result.

The image information concern such as Eigen values and coefficients that are bring from individual image through group of images using tools of MATLAB. From results of Table 1 the Eigen values and coefficients that obtained from fusion of MRI and CT Brain Images in this paper are more better than those parameters are registered in Ying et al. so the fusion image results with higher resolution and contrast.

Fused image is extracted pixels along with coefficients and carried out in Field programmable Gate Array Xilinx Spartan6-SP605 device by taking advantage of analyzed power and area reduction. The technology of FPGA provides low power, compact and fast solution of fusion image. The FPGA image implementation can be utilizing in the domain of medical applications and results with high quality resolution.

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