

# Gabor Filter Design for Fingerprint Application Using Matlab and Verilog HDL

R.Dhanabal\*,V.Bharathi\*\*\*,G.Prithvi Jain\*\*, Ganeash Hariharan\*\*,P.Deepan Ramkumar\*\* ,  
Sarat Kumar Sahoo\*

\*Professor, Department of ECE, Vellore institute of technology,

\*\*Student, Department of ECE, Vellore institute of technology,

\*\*\* Asst.Professor,GGR college of engineering ,  
Vellore

rdhanabal@vit.ac.in\* ,bharathidhanabal@gmail.com\*\*\*,Prithu.jain1111@gmail.com\*\*  
ganny14@gmail.com\*\* deepan.ramkumar@yahoo.com\*\*

**Abstract**— This paper demonstrates the application of Gabor Filter technique to enhance the fingerprint image. This work produces change in Gabor filter design by increasing the quality of an output which helps in higher security applications. The incoming signal in form of image pixel will be convoluted by Gabor filter to define the Edge and vale regions of fingerprint. The main characteristic of this paper is to store image pixel in memory if convolution signal is low and if the signal is high image is filtered.

**Index Terms**—Digital Gabor flter,Fingerprint , Kernel Coefficient, Matlab, Modelism, Xilinx.

## I. INTRODUCTION

Fingerprinting is the most affordable and at the same time the best way for security and are included in some important documents such as Personal identification, Personal accounts, Personal Motor identity, and others to avoid the use or access of unauthorized persons. The vale and their characteristics of our fingers are unique. Each person has different and unique edges on finger. The patterns of fingerprint are extensively modified but the accuracy of edges remained unchanged. Fingerprint image need to be very sharp and clear. Since in some cases there may be mismatches in fingerprint recognition if it is not so clear. Its main application is for security purpose and so the concentration will be more on the quality of output. Fingerprint image acquisition is considered to be the most critical step in an recognition system, as it produces the final fingerprint image quality, which is very important for overall system performance and to achieve a best quality, Gabor filter otherwise known as edge detecting filter is used.

This project is mainly to improve the quality of an input fingerprint image by the use of Gabor filtering techniques [1] where the input image is segmented based on the color texture and filtered. Kernel coefficients [6] of a fingerprint is used here since the original fingerprints are not to be disturbed in the filtering process. Gabor filter is widely used for edge detection and extraction of image textures, Suppression and also for object contour detection, and visual perception effects.

Digital Gabor Filter was designed by transforming the design into Verilog using Modelsim and Xilinx 14.1[8]. The input was generated from the MATLAB R2012a [4] and those pixel were taken into consideration. The target device is Spartan 6 family.

### A. Digital Gabor Filter

**Gabor filter**, is a linear filter used for edge detection in image processing. Frequency and orientation representations of Gabor filters are similar to those of the human neural – visual network, and it is also an appropriate model for texture representation.

$$\text{Gabor} = \text{Gaussian} * \text{Fourier}$$

Its impulse response is given by multiplication of a harmonic function with Gaussian function. Because of the convolution process [7], the filter has both real and an imaginary component which was represented in orthogonal directions. These two components may be combined into a complex number or can also be used individually [12]

Complex

$$g(x,y;\lambda,\theta,\Psi,\sigma, ) = \exp(-(x'^2 + y'^2)/2 \sigma^2) \exp(i(2\pi x' / \lambda + \Psi))$$

Real

$$g(x,y;\lambda,\theta,\Psi,\sigma, ) = \exp(-(x'^2 + y'^2)/2 \sigma^2) \cos(i(2\pi x' / \lambda + \Psi))$$

Imaginary

$$g(x,y;\lambda,\theta,\Psi,\sigma, \gamma) = \exp(-(x'^2 + y'^2)/2\sigma^2) \sin(i(2\pi x'/\lambda + \Psi))$$

Where  $x' = x\cos\theta + y\sin\theta$  and  $y' = -x\sin\theta + y\cos\theta$

In this  $\lambda$  denotes the wavelength of the sinusoidal factor, and  $\theta$  represents the orientation of the gabor function,  $\Psi$  denotes the phase offset,  $\sigma$  denotes the Gaussian envelope and  $\gamma$  denotes spatial aspect ratio.

## II. PROJECT APPROACH

### A. Design

**Image processing** is any form of signal processing for which the given input is an image file that is photo or video and the output generated is not necessary an image, it can also be a list of values or parameters depending on the requirement of the design. Most image-processing techniques involve treating the image as a two-dimensional signal [2]

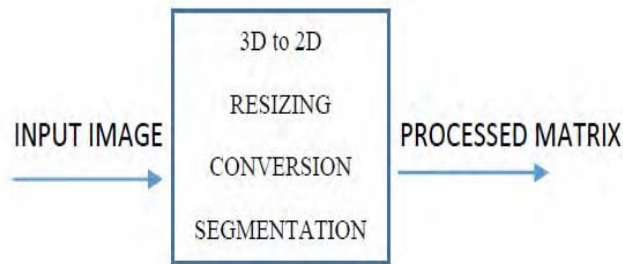


Fig.1 Image Processing

The conversion of 3d images into 2d in the design is much important to implement because the input can be in any dimension but the processing is done in 2d and so conversion is necessary Resizing the image into standard size is another part of conversion because we need one fixed size to process.

Now, Image is converted into the pixel matrix to process as per the conditions and we fix one default sized matrix, then these pixels are converted into hexadecimal values to reduce the memory. At last the output of the default pixels are segmented depending upon the coefficients into a default sized matrix. Kernel coefficient [6] values with which the convolution process will take place are shown in fig.2.

S.No	Kernel Coefficients
1	0.006737943
2	1.29E-05
3	-4.00E-08
4	2.36E-07
5	4.41E-08
6	1.45E-12
7	-1.36E-11
8	2.65E-14
9	8.53E-17

Fig.2 Kernel/Gabor coefficients

From fig.3 the processed matrix which is taken as IMG [63:0] and the coefficients are referred as COEFF [63:0] was convoluted and the filtered output is generated as FILTERED\_VALUE [127:0] and DATA\_OCCUR is 'high' when IMG [63:0] has been assigned to temporary memory location.

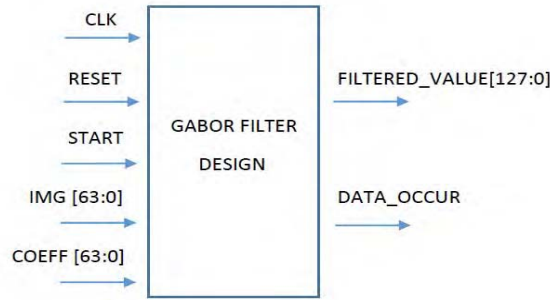


Fig.3 Gabor Filter Design

III. ALGORITHM AND FLOWCHART

A. Algorithm:

STEP 1:

Initially, when the convolution signal is '0' the input data which is in pixel format will enter the filter and stored in the memory. In ALU there is also a ROM which will store the Kernel coefficient. All the kernel coefficients are fixed values

STEP 2:

When the convolution signal is triggered to '1', then the convolution process starts and the convolution takes place between the memory and coefficients inside the MAC unit.

STEP 3:

It takes 1 complete cycle to complete STEP 2, only one series of data will be convoluted at a time.

STEP 4:

The design will count for 9 convolution operation before giving out the result of filtered image. Since there is 9 coefficient values it takes 9 consecutive cycles, which will result in output of the filter.

STEP 5:

And if the convolution signal is '0' the control will go to STEP 1 and if not the filtered output is obtained.

B. Flowchart:

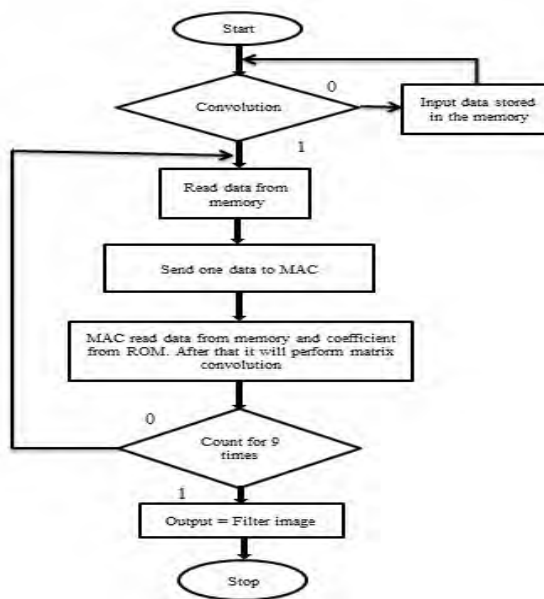


Fig.4 Flowchart of convolution process

IV. RESULTS AND DISCUSSION

A. Image output

The input fingerprint image has been filtered and the clear output image has been obtained shown in fig.5

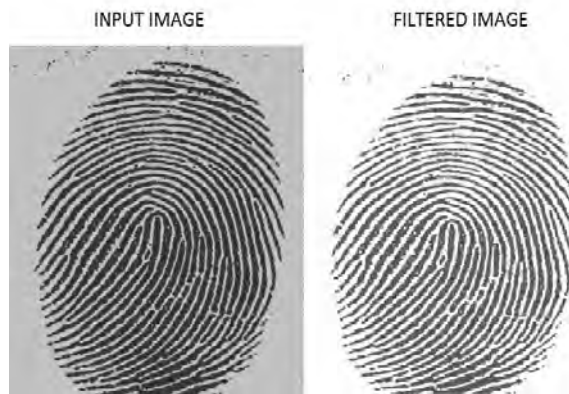


Fig.5 Comparison of Input and Output Image

B. Waveform

The waveform obtained from the convolution process done in MODELSIM shown in fig.6

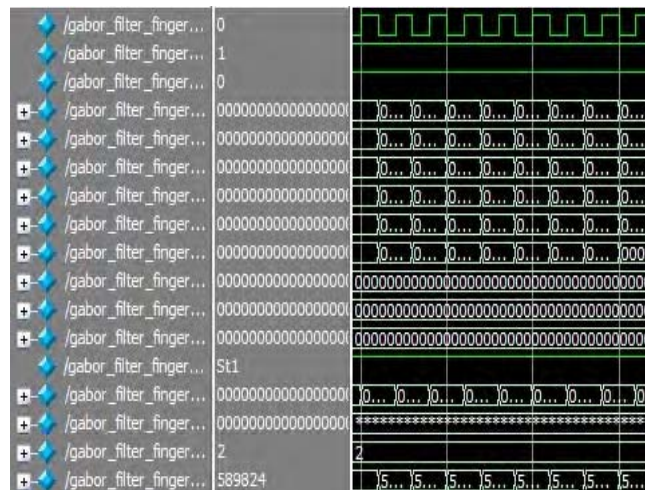


Fig.6 Waveform

C. Synthesis report

This paper can be implemented in FPGA and the report of synthesis done in Spartan 6 family is shown in fig.7

Initially this design was implemented in Spartan 3E. It utilizes more memory and clock cycles and hence to avoid this issue we have implemented in Spartan 6 family. This produces considerable result and faster. This project can be further improvised by implementing on higher version boards.

gabor_filter_finger_image Project Status (03/14/2013 - 15:47:04)			
Project File:	Prithvi.vise	Parser Errors:	No Errors
Module Name:	gabor_filter_finger_image	Implementation State:	Synthesized
Target Device:	xc6slx25t-3csg324	•Errors:	No Errors
Product Version:	ISE 14.1	•Warnings:	1 Warning (1 new)
Design Goal:	Balanced	•Routing Results:	
Design Strategy:	Xilinx Default (unlocked)	•Timing Constraints:	
Environment:	System Settings	•Final Timing Score:	

Device Utilization Summary (estimated values)			
Logic Utilization	Used	Available	Utilization
Number of Slice Registers	384	30064	1%
Number of Slice LUTs	6038	15032	40%
Number of fully used LUT-FF pairs	384	6038	6%
Number of bonded IOBs	708	190	372%

Fig.7 Synthesis Summary

D. Comparison of device used

We have implemented this design in Xilinx 14.1 and the target device is xc6slx25t-3csg324 (Spartan 6). It was also checked in previous version Spartan 3E and the comparison is done shown in fig.8

S.No	Device Params	Spartan 3A	Spartan 6
1	No.of.Slices	818%	1%
2	No.of.Slice Flip Flop	615%	40%
3	No.of.4 input LUTs	552%	6%
4	No.of.bonded IOBs	29%	372%
5	Warnings	10	1

Fig.8 Comparison of Device Used

Graphical representation of device comparison can be referred in Fig.9 and Fig.10

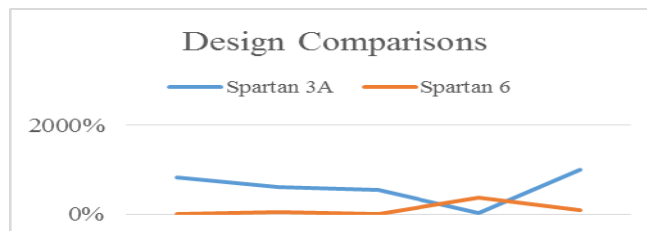


Fig.9 Design Comparison 1

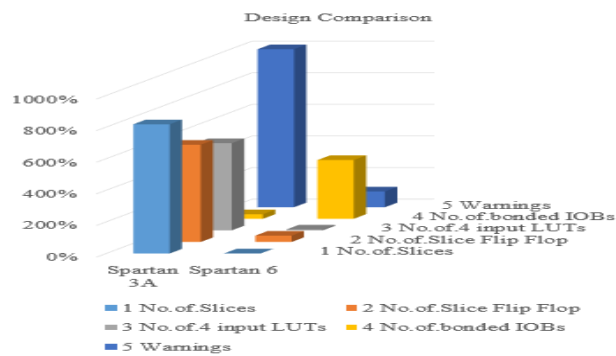


Fig.10 Device Comparison 2

## V. APPLICATION

This design can be effectively used for security and criminal investigation purposes. We can also implement this design in various fields like Biomedical, Defense. This design can be used in Acoustic application i.e to load audio databases.

## VI. CONCLUSION

Gabor Filter design for Fingerprint have been successfully completed. The area of the design has been significantly reduced but the function of the filter is perfectly maintained. The numbers of slices obtained from the previous design was reduced from 4488 slices to 384 with a utilization of 1%. This design is used as one of the module in all security databases and since the world is getting worse in security, its very important to concentrate on personal security and since fingerprint differs for every individual, this gives a perfect individual security. In future this design can be taken into consideration and can be implemented in many real time applications as discussed above.

## VII. ACKNOWLEDGEMENT

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**PROF.DHANABAL.R**  
Asst professor (Sr) in SENSE,  
Vellore institute of technology  
Vellore. His research area is  
Low power VLSI design.



**GANEASH HARIHARAN**  
Pursuing B.Tech in Electronics and Communication Engineering at  
Vellore institute of technology,  
Vellore



**DEEPAN RAM KUMAR.P**  
Pursuing B.Tech in Electronics and Communication Engineering at  
Vellore institute of technology,  
Vellore



**PRITHVI JAIN.G**  
Pursuing B.Tech in Electronics and Communication Engineering at Vellore institute of  
technology,  
Vellore