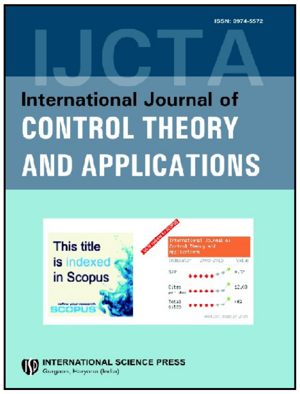

International Journal of Control Theory and Applications

ISSN : 0974-5572

© International Science Press

Volume 10 • Number 11 • 2017

VLSI Implementation of SVM Based Offline Signature Verification Algorithm

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Abstract: This paper presents the VLSI architecture for the signature recognition in biometrics. In the field of Bank-cheque processing, document authentication, ATM access etc. automated signature verification has many applications. Who is signing the document is a matter of concern today. In this paper a SVM based offline signature verification algorithm has been proposed. The local and structural parameters are utilized for the purpose. Every signature has a unique variation in the features. These form the basis for training the SVM classifier. The proposed method is extracting many such features which make the algorithm robust. The hardware results were simulated using ModelSim and realized on Spartan 6 FPGA.

Keywords: VLSI, FPGA Implementation, Signature Verification, Image Security, SVM.

INTRODUCTION

Biometrics refers to the automatic identification of a person based on his/her physiological or behavioral characteristics. Thus, biometrics can be defined as the science and technology of measuring and statistically analyzing biological data. Physiological characteristics are based on measurements of data derived from direct measurement of a part of the human body. Fingerprints, hand geometry, and retina, iris, and facial images are leading physiological biometrics. Behavioral characteristics are based on an action taken by a person. Behavioral biometrics, in turn, are based on measurements of data derived from an action, and indirectly measure characteristics of the human body. Signatures, voice recordings (which also has a physiological component), and keystroke rhythms are leading behavioral biometric technologies, the terms "Biometrics" and "Biometry" have been used since early in the 20th century to refer to the field of development of statistical and mathematical methods applicable to data analysis problems in the biological sciences. Recently, these terms have also been used to refer to the emerging field of information technology devoted to automated identification of individuals using biological traits especially for authentication purposes.

In general, the verification system falls into two broad categories according to the biometric technology which is applied. One is the online signature verification system and the other is the finger vein system. Even for the signature verification system, the system splits into separate systems depending on the classification method.

Figure 1 shows the three separated signature verification systems each one of them using different classification methods while Figure 1.3 shows the two biometric systems signature verification and finger vein.

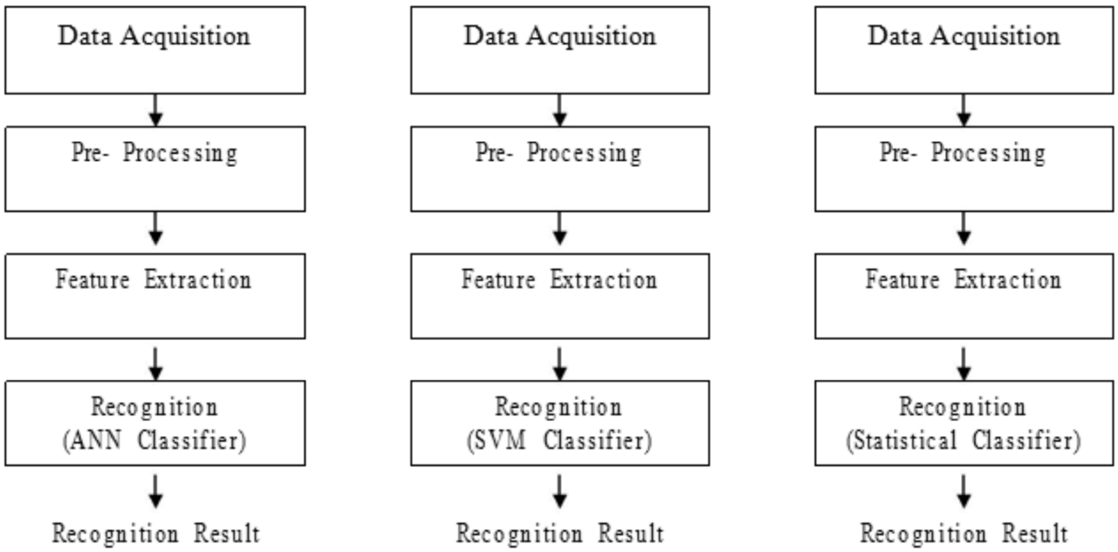

Figure 1: Signature verification systems using different classification methods

PROPOSED WORK

The proposed approach aims at developing automatic offline signature verification and forgery detection system. Fig. 1 shows the algorithm that is used in order to build the automated signature verification and forgery detection system. The proposed system has been divided into two parts namely:

- Training
- Testing

(A) Training Phase

In the training part of the system, the following steps are performed:

1) Image Database: The images are collected for training and are stored in a database. The images are collected by scanning them from a physical paper source. The database used is a self-created database which contains signatures of three different people. The database consists of fifteen signatures belonging to each person, and summing up to be forty-five signatures in total. More signatures can be added to the database easily and also the number of signatures per person can also be increased or decreased.

2) Pre-Processing: In this step, each of the scanned signature goes through a series of pre-processing steps which include the following[15]:

   a) Image Resizing**:** The image is resized to a predefined size of 128 x 128 pixels.

   b) Binarization: After resizing the image, the image is binarized, i.e. it is converted to black and white [14].

   c) Thinning: After the process of binarization, the image goes through the process of thinning, i.e. the thickness of the strokes of the signature is thinned down to a single pixel. It is done is order to exclude the variations in thickness of signature which may occur due to the use of different types of pens.

d) Rotation: The image is then rotated on the basis of the lower most pixels. When a person signs a document, depending on the writing style of the person, there is a certain angle to the signature in which it is done. This process straightens out the signature.

e) Cropping of the image: After the image is rotated, the excess area around the signature is removed and the image is cropped to the outer most pixels in four directions, i.e. top, bottom, left and right.

3) Feature Extraction: After the image has gone through the pre-processing, various features are extracted from the image. The extracted features out of each image are then stored in a MATLAB file. Following unique features are extracted from each the images:

a) Height-Width Ratio: After the image is cropped, height-width ratio of the signature is calculated.

b) Centroid of Signature**:** The centroid or the barycentre of the image is calculated. The centroid gives the central point of the signature which is a unique signature characteristic. The signature is broken down vertically into two halves, and the centroid of the each half is calculated.

c) HOG: We first divide the image into 9 blocks. For each block we find the 1st derivative of the image is found in the x and y direction. We find the orientation of the image. Further we find the histogram of the orientation in 9 bins. These histograms are stacked for all the 9 blocks.

d) Quadrant Areas: The image is broken down into four quadrants, and then the area of the signature pixels in each quadrant is calculated. This area is the area of strokes of the signature in that particular quadrant and does not include the area of the background.

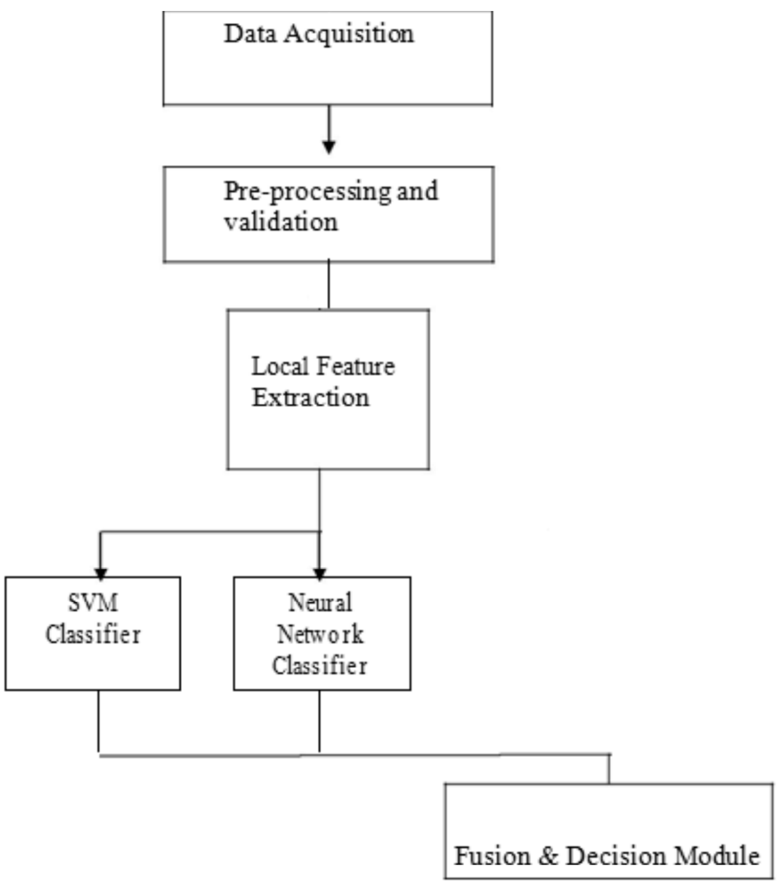

Figure 2: Block Diagram for Proposed Method

e) COM Matrix: COM Matrix or Co-Occurrence Matrix refers to the distribution of the co-occurring values at a given offset. It is used to measure the texture on the image. What is does is, as our image is in black and white after the pre-process, that means the image matrix has values either 0 or 1. It looks for pattern distribution of these values and looks where the patterns 00, 01, 11 and 10 occur. The cooccurrence matrix is also calculated for the signature.

f) Edge Point Calculation: The number of edge points in the signature are calculated which gives a distinct characteristic about the signature.

g) Horizontal and Vertical Histogram**:** Each row and each column of the signature is gone through and the number of black pixels is calculated. The row and the column with the maximum number of black pixels is recorded and used as a feature. All these features give out unique characteristics about the signature and are used for classification of the signatures.

4) Generate Training Feature Set and training svm: All the features calculated are stacked together to form the feature set. This is calculated for all the training images. All the feature sets are then used to train the SVM classifier. This gives us a hyperplane which can distinguish between the signatures.

RESULTS

The algorithm has been developed in Matlab on intel i3 with 4GB RAM. The algorithm has been tested for the training set as well as testing set. In the training set we get 100% accuracy and in the testing set we get some statistics which is shown in table 1.

Table 1
Comparison Table for Neural Networks and SVM

	Neural Network	*SVM with modified features*
tp	50	50
fn	7	2
fp	7	2
recall	87.7	96.15
precision	87.7	96.15

Some results are shown in the figures below. The signatures have lot of variance in the images. Figure 3 and 4 can be compared and it can be seen clearly that the signatures have a lot of variance. Similar analysis can be done in figure 5 and 6.

Figure 3: Signature 1

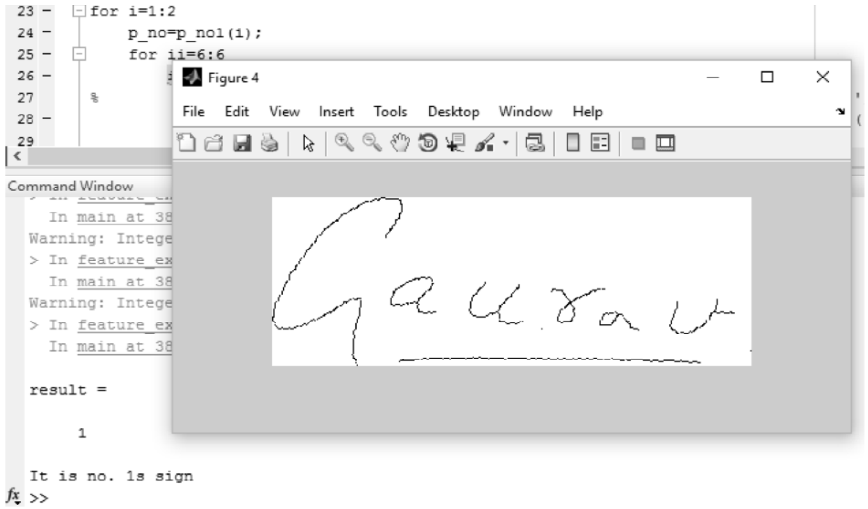

Figure 4: Signature 2

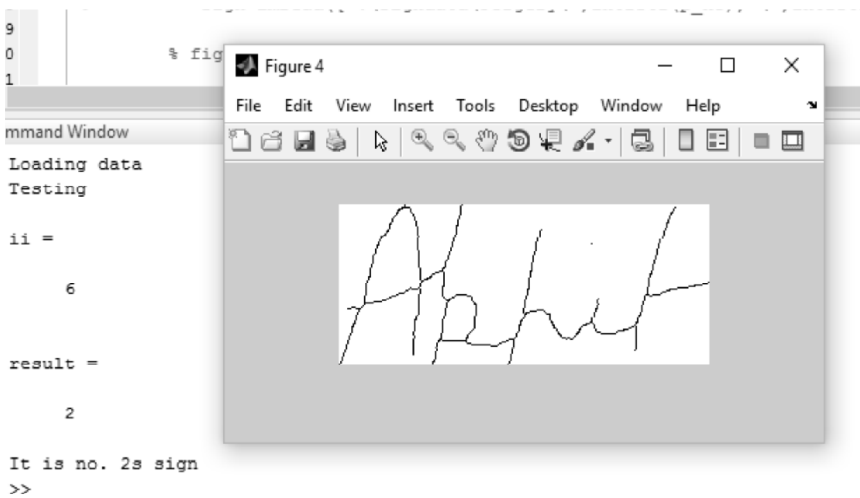

Figure 5: Signature 1

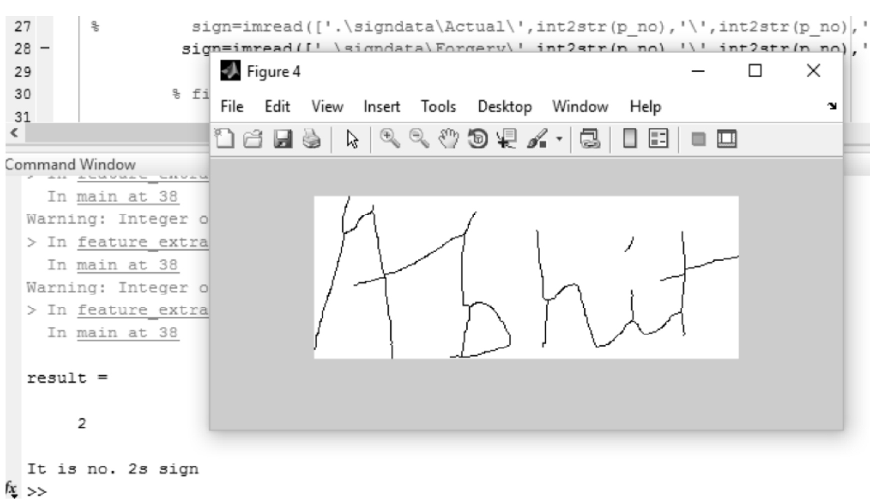

Figure 6: Signature 2

Hardware Realizations

For the hardware realizations the code was developed in Verilog HDL and realized over Spartan 6 FPGA. The HDL code was simulated using ModelSim. The results are demonstrated below.

Preprocessing and Feature Extraction

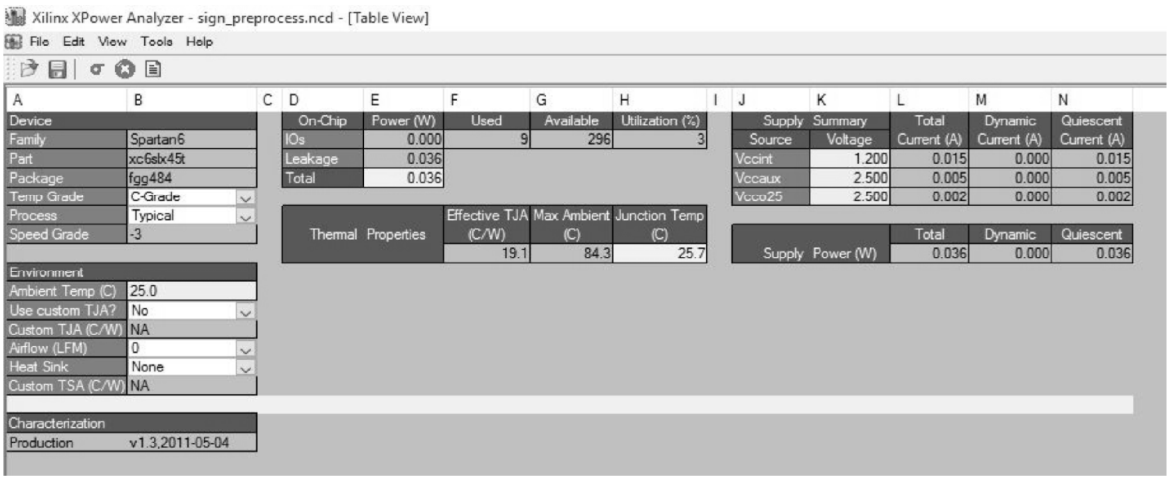

Figure 7: Power Report for Preprocessing and Feature Extraction

Device Utilization

Device Utilization Summary (estimated values)			
Logic Utilization	**Used**	**Available**	**Utilization**
Number of Slice Registers	75	54576	0%
Number of Slice LUTs	133	27288	0%
Number of fully used LUT-FF pairs	67	141	47%
Number of bonded IOBs	10	296	3%
Number of Block RAM/FIFO	36	116	31%
Number of BUFG/BUFGCTRLs	1	16	6%

Figure 8: Device Utilization Results for PreProcessing and Feature Extraction

Testing by SVM classifier

Device Utilization

Device Utilization Summary (estimated values)			
Logic Utilization	**Used**	**Available**	**Utilization**
Number of Slice Registers	133	54576	0%
Number of Slice LUTs	10664	27288	39%
Number of fully used LUT-FF pairs	71	10726	0%
Number of bonded IOBs	3	296	1%
Number of Block RAM/FIFO	4	116	3%
Number of BUFG/BUFGCTRL/BUFHCEs	1	16	6%

Figure 9: Device Utilization Results for Testing by SVM

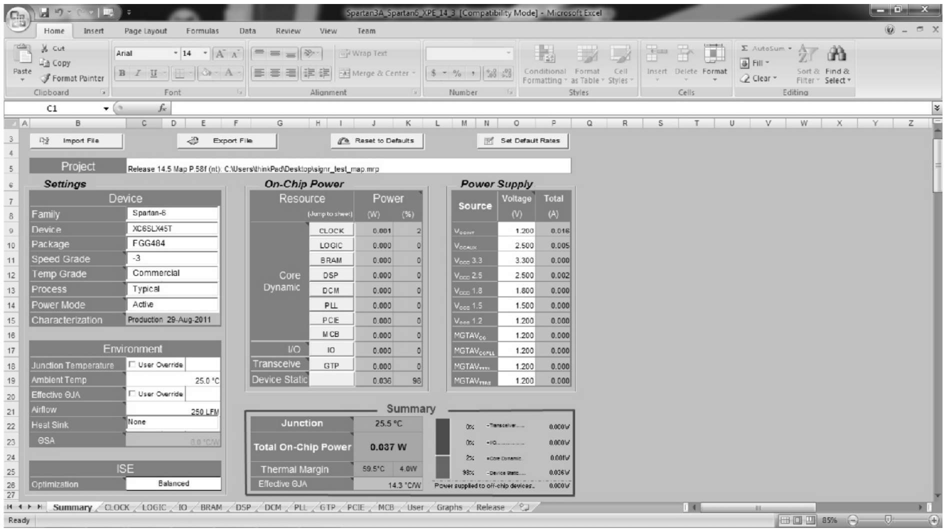

Figure 10: Power Report for Testing by SVM

SIMULATION RESULTS

Simulations were carried out for 4 different feature sets, two for each signature.

166 features for one signature. SVM classify is used for signature recognition.

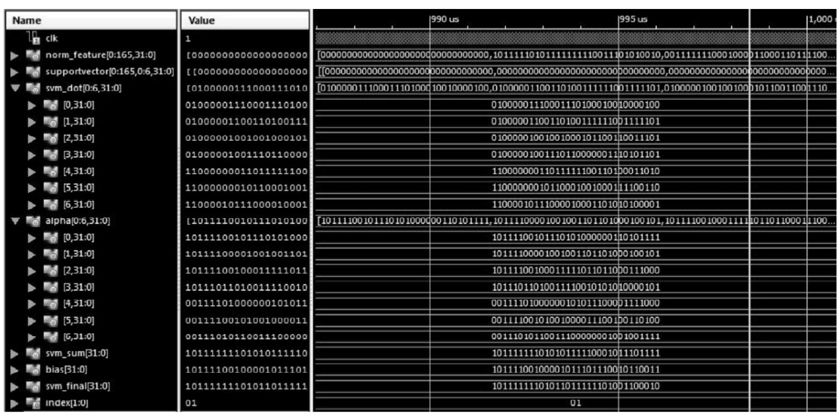

Figure 11: Simulation Resuts for Signaure 1

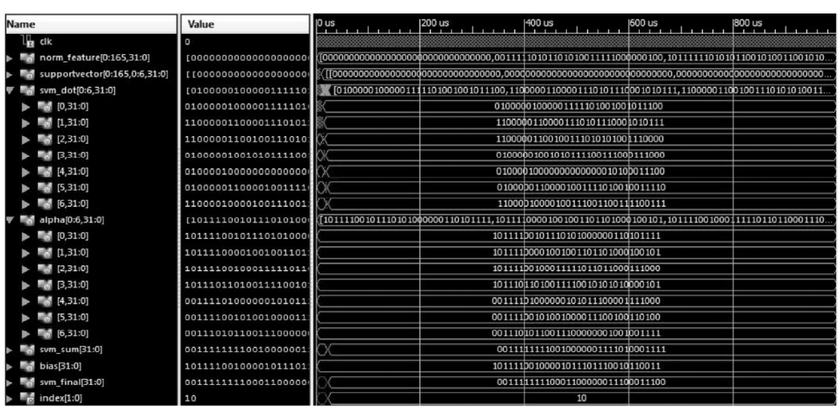

Figure 12: Simulation Results for Signature 2

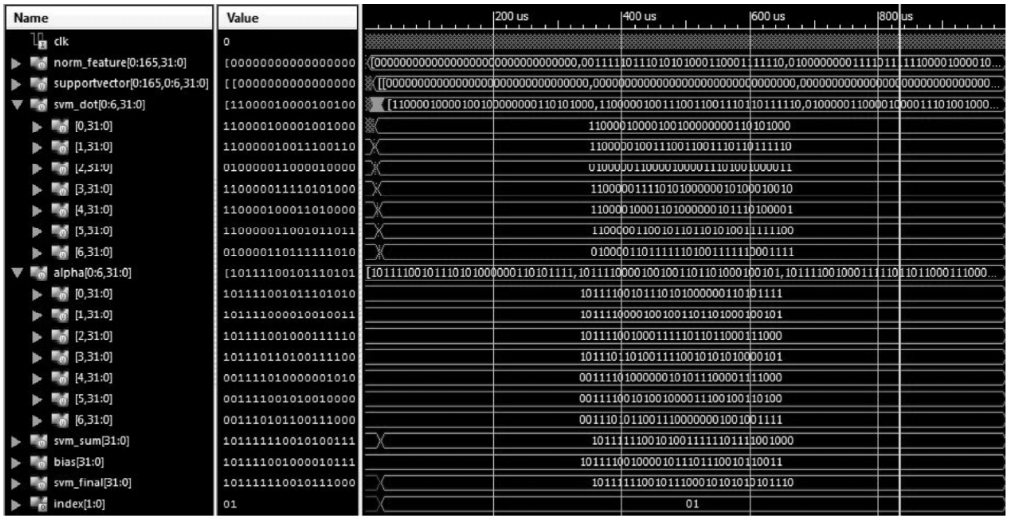

Figure 13: Simulation Result for Signature 1

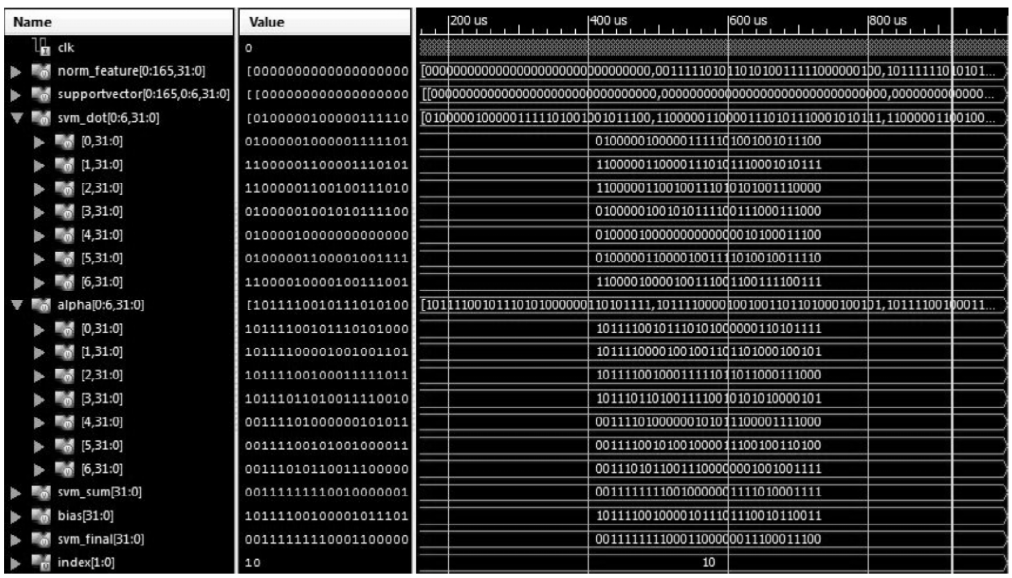

Figure 14: Simulation Results for Signature 2

CONCLUSION

The paper presented a VLSI implementation for verification of offline signature. The method provides robust results. The system having this algorithm can be used in ATM's, document authentications and banks. The emotion and situation of the person doing signature may affect his/her signature. This can be improved in the future.

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