QR Code Based Signature Encoding System

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Abstract—*Signature on a paper is a most general authentication method used in the world. Personal signature plays significant role in a place like Bank in money transactions. A signature encoding system provides secure reliable and fast money transaction.*

Banks need to handle thousands of transactions in a second. Therefore signature should encode to very simple form. QR code would be one of feasible solution in that context. QR code could use as simple encoded symbol that represent signature. This paper discusses a QR code based signature encoding system implemented with an FPGA based hardware platform to increase the speed of encoding.

The image of the signature is used to generate QR code. Direct generation QR code from the webcam image is not possible. Therefore image is pre compressed before encoding. First the input image is normalized and its contrast is enhanced by using histogram equalization. It is converted into a binary image and Binary image matrix is compressed into a simple matrix using two-dimensional wavelet analysis.Two matrixes are produce as output. One matrix consists of coefficient information and other matrix consists mapping detail. The matrix consist of mapping detail is converted to a QR code. Matrix which consist coefficients is stored as secondary information for decoding process.

The system is implemented in FPGA based embedded system with a webcam interface.By using this method the signatures are encoded with accuracy around 60% and about 65% differentiation accuracy of two different signatures was observed.

Keywords— QR code, Signature Verification, Wavelet Analysis and FPGAs.

I. INTRODUCTION

Signature on paper is a one of the general authentication methods used in the world. Even though the duplication of one's hand signature by another is difficult, faking another's signature is very common security violation. Also it is sometimes very hard to identify real signature from fake signature using naked eye at a glance. Banking is a one system that personal signatures play key role in money transactions. High transaction volume environments in banks often lead to false signature verifications. One method that used to retrieve one's personal signature is bank pass book. Currently there is no any method have been used for security of the customer's signature. Some banks are used simple encoding systems but it is not enough to mitigate misguiding banks in transactions. A digital signature encoding system is one of afeasible solution(RevathiM K et.al ,2013).

The signature encoding is a process that encrypt signature and display it on different format. It is difficult to retrieve signature again without knowledge on encoding method. The encoding method for bank should

- process fast
- Reliable and consistence in encoding
- Capable of adopting with online signature verification system

Quick response code (QR code) is a best solution according to the above constrains. According to DENSO ADC (2011)a Quick response code (QR code) is matrix symbology that represent numeric or alphanumeric data. It is a two-dimensional barcode in square shape. Three unique square pattern for easy location and all date in square pattern. QR code is a machine readable barcode symbol that could represent 7089 maximum numerical characters in a one symbol. Dark modules represent binary one and light modules are represent binary zero. Symbol size depends on the version and there are 1 to 40 versions and maximum version size is version 40-L(ISO,2000).

Digital image of a signature is used for encoding.Direct encoding of a signature image to QR code is not possible(ISO,2000). Generally digital true color image is a three-dimensional matrix and it processed before convert in to QR code. Input image undergo wavelet de-noising process and convert to an index image. Wavelet decomposition

techniques are used to decompose image. Decomposition produces two matrix C and S where C is coefficient matrix and S bookkeeping matrix(Walnut, David F ,2003)). Matrix S is converted into a QR code and matrix C is processed online while retrieving process.

A FPGA based embedded system is used to implement the application and it provide fast processing speed to the system(Yue Liu&Mingjun Liu, 2006). Embedded type system enhances the portability and looks handy while used. Web cam is used for image capturing.Only the encoding methodology is discussed in the paper. Decoding process is complete invers process of the encoding. The QR code generated by proposed system is printed on the bank pass book. It is scanned and use as primary information in the decoding process while Matrix C which is processed online is used as secondary information to retrieve customer's signature by the system. Finally generated signature could be verified with the signature in the document. The methodology of the encoding system is discussed in section 2 and experimental results are given in section 3. Finally conclusion is given in section 4.

II. METHODOLOGY

The encoding process consists of four main steps. Signature on the paper captured as digital image, image contrast level enhancement and extraction of image color map is done in first step. It is call as pre-processing step. De-noising is done at the second step. The de-noised image decomposed using wavelet analysis in the third step. One output matrixes of the decomposition process are used to generate QR code in the fourth step. Second matrix is saved as secondary information for the decoding process. Figure1 shows steps of the encoding process.

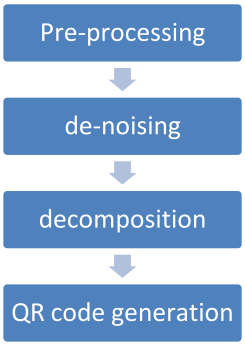


Figure 1. Steps of the encoding process

A. Pre-Processing Step

The signature is in fixed scaled box on white paper and signed in black or blue color. The image of the signature is taken form web cam and it is in RGB color space.Captured image is shown in Figure2.Color map of the input image extracted. Image maycontain noise concatenate due to light variation of the environment. A simple histogram equalization process is used for enhance the contrast of the image.it maps intensity values of the image to a new intensity values such that new values match to pre define flat histogram(Rajesh Garg te.al2011). The RGB image converted to grayscale imagebefore histogram equitation (see Figure3). The image after histogram equalization is in Figure4. The processed image is used for de-noising process.

Figure 2: Input Image

Figure3: Grayscale image

Figure4: After histogram Equalization

B. De-noising Step

*1) Wavelet based image de-noising:*Let a signal $\{f_{ij}\}$ is concatenate with nioseσn_{ij} where $\{n_{ij}\}$ is independent identically distributed zero mean gaussian noise with standard deviation σ. therefor the signal with noise isg_{ij}(see equation 1)

$$g_{ij} = f_{ij} + \sigma n_{ij} \quad (1)$$

The sub bands of wavelet transformation are HH^k, HL^k,LH^k are detail coefficients and k is the decomposition level. The sub band LL^k is the lowest resolution residual. Each coefficients of the detail sub band filtered with threshold function to form modified coefficient. The soft thresholding function (see equation 2) and hard thresholding function (see equation 3) are used commonly in wavelet thresholding de-noising method(RohitSihag et.al,2011)

$$\eta_T(x) = sgn(x).\max(|x| - T, 0) \quad (2)$$

$$\psi_T(x) = x.1\{|x| > T\} \quad (3)$$

Wavelet de-noise techniques are used to smoothen the image. A fixed threshold is used according to the input signal noise level. Soft thresholding mode is used and approximation coefficients are kept (Walnut, David F ,2003)). De-noised image is continued to decomposition process. Figure 5 shows the de-noised image.

Figure 5: De-noised image

C. Decomposition Step

*1) Biorthogonal wavelet analysis:*Two hierarchies of approximation subspace are defined as $v_i$and$\overline{v_i}$,where v_i are spanned by the translation of scale function Φ and $\overline{v_i}$ are spanned by dual scale function Φ. Wavelet subspace w_i anddual wavelet subspace $\overline{w_i}$ are defined. The wavelet subspace w_i is orthogonally complimentary to $\overline{v_i}$ and on the other hand $\overline{w_i}$ is complimentary tov_i. Wavelet subspace w_i is complimentary to scale subspace v_i in the fine resolution and not orthogonally compliment. The orthogonality between wavelet and dual scale functions and between dual wavelet and scale subspace are shown in equation 4 and 5

$$\langle \bar{\Phi}(t-k), \psi(t-n) \rangle = 0 \quad (4)$$

$$\langle \bar{\psi}(t-k), \Phi(t-n) \rangle = 0 \quad (5)$$

The orthogonality between scale function, wavelet and their duals are in equation 6 and 7

$$\langle \bar{\Phi}(t-k), \Phi(t-n) \rangle = \delta_{k,n} \quad (6)$$

$$\langle \bar{\psi}(t-k), \psi(t-n) \rangle = \delta_{k,n} \quad (7)$$

The orthogonality in above four equations is refers as biorthoganality(Sheng, Y,2000).

2) Biorthogonal wavelet decomposition:The biorthogonal wavelet decomposition is implemented with biorthogonal low pass filter $P(n)$ and biorthoganal high pass filter $q(n)$ as in equation 8 and 9. Where c_i and d_i are approximations of biorthogonal low pass filter and biorthogonal high pass filter(Sheng, Y,2000).

$$C_i(k) = 2^{-1/2} \sum_n p(n-2k)\, c_{i-1}(n) \quad (8)$$

$$d_i(k) = 2^{-1/2} \sum_n q(n-2k)\, c_{i-1}(n) \quad (9)$$

3) Biorthogonal wavelet Reconstruction:The reconstruction with the biorthogonal analysis filters $p_0(n)$and $q_0(n)$ is as equation 7(Sheng, Y,2000).

$$C_{i-1}(n) = 2^{-1/2} \sum_n c_i(k) p_0(n-2k) + 2^{-1/2} \sum_n d_i(k) q_0(n-2k) \quad \ldots\ldots\ldots\ldots (10)$$

4) Biorthogonal wavelet decomposition of signature image: De-noised image is undergoing two-dimensional biorthogonalwavelet decomposition using biorthonagal filter in order 3.7. Wavelet decomposition convert image into two matrixes. Third level decomposition is performed and two matrixes given as output. First matrix (Matrix C) consists of approximation coefficients and detail coefficients of the image and second matrix (Matrix S) consist of mapping detail of the image(Walnut, David F, 2003)). Matrix C has more than 1000000 numerical characters and it is used as secondary information at the decoding process. Mapping matrix is a 5X2 matrix and it is converted to a QR code.

D. QR code Generation Step

The QR code generated using mapping matrix is identical to one's signature. The QR code is printed in the bank pass book and it is used as primary information in the decoding process with the relevant matrix C which has saved with the

customer's account number. The QR code generated using matrix S is shown in Figure 6(DENSO ADC, 2011).

Figure 6: QR code generated using Matrix S

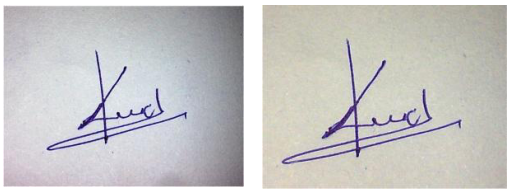
The encoding system was implemented as FPGA based embedded system. Web cam directly connected to the embedded system. System communicates with PC for online data processing and printing process. Embedded system was developed as a portable device which could connect to PC directly.

III. RESULTS

Propose encoding process was tested with 50 different signature images. The QR code totally depends on matrix S and therefore matrix S is used for comparison.

A. Signatures of Same Person

System was tested with 10 signatures of same person and matrix S compared with each other. Signature of a same person is different in different trails. Therefore matrixes of 10 signatures are different and the average matrix is used for QR code generation. Figure 7 shows matrixes of two signatures in two trials of same person

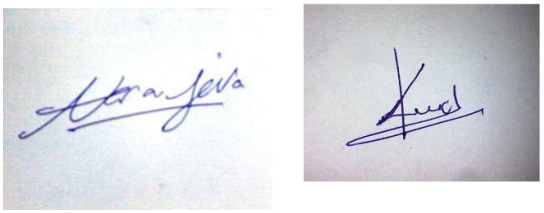


88 113	73 93
88 113	73 93
161 211	131 171
307 407	247 327
600 800	480 640

Figure 7.Two S matrixes for two trails of same person

B. Signature of Different Persons

Matrix S for the signature images of different person shows clear deference and S matrixes that produced by two different signatures are in Figure 8.



163 213	88 113
163 213	88 113
311 411	161 211
607 807	307 407
1200 1600	600 800

Figure 8. S matrixes of two different person's signatures

C. Regeneration of Signature from Image

The encoded signature was regenerated using QR code and matrix C which has saved as secondary data. The signature regenerated using wavelet approximation coefficients. The input signature and regenerated signature are in Figure 9.

Input signature Regenerated signature

Figure 9.Input signature and regenerated signature

IV. CONCLUTION.

The proposed signature encoding system discusses only the encoding process. System was tested and depending on the results signature encoding based on QR code is a feasible and reliable method. The proposed signature encoding system provides simple, secure and reliable signature encoding. The QR code based system facilitate simple encoded symbol. Regeneration of a signature is only possible with matrix C which contains coefficient data of the image. It caused to improve the security of the encoding system and signature regeneration possible with the system only. The bank pass book contains the QR code only.

Other main advantage of the proposed system is that it is compatible with current system used in the banks. Therefor no changes need to adapt with

proposed system. On the other hand proposed system is support to online signature verification system also. Therefor proposed system could easily upgrade to an online signature verification system. Proposed system was implemented in a FPGA based embedded system and that will provide robustness and portability. The matrix C which has to process online is kilobyte rage in capacity and it enables fast processing.

But there are few drawbacks in the system. The difference of the signature in different trials is a challenging to the consistency of the proposed system. Therefor final matrix S and C produce as an average matrix if ten signature matrixes of a same parson. Ten signatures should be taken at the initial stage. Regenerating of the signature is done by approximation coefficients and that may lead to reduce some information of the signature. But the matrix C contains all coefficient details of the signature and that could be used for signature verification also. The proposed signature encoding system encoded signature with 60% accuracy and 65% differentiation accuracy for 50 signatures.

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REFERENCES

AbhasTandonet.al(2013).”QR Code based secure OTP distribution scheme for Authentication in Net-Banking”, International Journal of Engineering and Technology,Vol 5 No 3 Jun-Jul,p 2502-2504.

DENSO ADC, 2011.QR Code® Essentials, DENSO Wave Incorporated.

ISO,2000. Information technology — Automatic identification and data capture techniques — Bar code symbology — QR Code, ISO,Switzerland

Rajesh Gargte.al(2011).”Histogram Equalization Techniques For Image Enhancement”, International Journal of Electronics & Communication Technology,Vol. 2, Issue 1, March,p 107-111

RevathiM K et.al (2013).”Enhancing Security in Identity Documents Using QR Code”,International Journal of Research in Engineering & Advanced Technology, Volume 1, Issue 5, Oct-Nov.

RohitSihaget.al(2011).”Wavelet Thresholding for Image De-noising”,Proceedings published by International Journal of Computer Applications

Sheng, Y(2000), “Wavelet Transform “,The Transforms and Applications Handbook, 2nd ed,;CRC Press LLC

Walnut, David F (2003).*An Introduction to Wavelet Analysis*, 2nd ed.,:Birkhäuser Basel

Yue Liu, Mingjun Liu, (2006). “Automatic Recognition Algorithm of Quick Response Code Based on Embedded System,” *Proceedings of the Sixth International Conference on Intelligent Systems Design and Applications*.

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