FEATURE EXTRACTION AND IMAGE ANALYSIS USING KP AND LU DECOMPOSITION IN BIOMETRIC AUTHENTICATION

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Abstract— Generally, in several phases of human beings life, accurate uniqueness validation seems to be critical. Before the emergence of computing revolution, the issue security is for individual ensured after checking the someone in person and also with the help of the signature. It is observed that conventional methods of authentication is unproductive because any person can impress as a real person with the help of therapeutic procedure and through spoofing. Pattern recognition is one of the current and advanced technologies that focus on analysis and construction of pattern is a complex work. For recognition of patterns Vector logic gives good strategies. At present, authentication is made through offline and or online mode taking the distinctive features like biometrics of a person. The main use of the distinctive or unique features is that no one can duplicate the features of original human being. In the event of processing the biometric qualities, it is a complex process to derive authentication. In order to enhance accuracy, researchers have proposed diverse types of algorithms. During this process, finger and face traits of a person are considered and also decomposing and reconstruction techniques such as Singular Value Decomposition (SVD), Lower and Upper (LU) factorization and applications of Kronecker Product(KP) such as Khatri Rao Product are used. And then, two multimodal authentication systems using AT&T, FERET and Yale data sets are implemented.
Keywords— Biometric, SVD, LU factorization, Khatri Rao and Kronecker products

INTRODUCTION

In fact, the current society is electronically and digitally linked with the quick expansion of Computer Science, Information Technology, Digital communication and its tools. It is noted that the everyday transactions are done using inter-connected electronic devices between organizations, individuals and Governments i.e., banking, implementation of schemes and so on which is greater than ever exponentially. Currently, the researchers are using hand vein, hand geometry, face, ear, fingerprint, iris, voice print and signature as biometric traits for intensive evaluation extensively [1, 2, 5, 6]. Various statistical and computational models are on hand for processing an evaluation and each of them has its own pros and cons with respect to the performance and acceptance [5, 9, 13].

The classification of Authentication systems using biometric traits is done in different ways: One is unimodal or one mode biometric system where a single trait can be used for authentication and another is characterized by different modes also called as multimodal authentication system that uses a blend more than two impressions [5, 6]. In case of operating authentication system using biometric professionally in various organizations or sectors, a multimodal biometric system [5, 6, 13] is considered. The rest of this paper is organized as follows: section-2 includes feature selection and extraction with kernel products is explained. Section-3, section-4 explains the framework of the proposed model-1and model-2 using PCA, LU, SVD and Khatri Rao Products along with the results is presented and finally section-5 presents the conclusion of the work.

FEATURE SELECTION AND EXTRACTION

A. Vector Logic

Vector logic is a mathematical representation of matrix algebra [3] stimulated in the areas of image processing. In this, the image is represented as matrix to compute eigen values and eigen vectors as

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feature vectors. In matrix algebra, Kronecker product is one of the key products[3, 4, 7, 8], which computes in the areas of image segmentation, analysis and security models. The data elements can be represented as monadic, dyadic and so on. In monadic, the data is represented as one dimensional, whereas in dyadic representation data is stored in the form of rows and columns [11].

B. Convolution Kernel Products

In the present research the convolution kernel products [5, 6, 11] such as Kronecker Product and its application like Khatri Rao are used in the areas of image processing for its exactness and effectiveness.

C. Kronecker Product

The Kronecker product is a special case of tensor product of two matrices denoted by P⊗Q, and has several properties [3, 4, 5, 6] and are

1. P⊗(Q⊗R) = (P⊗Q)⊗R associativity,
2. P⊗(Q+R)=(P⊗Q)+ (P⊗R), (P+Q)⊗R =(P⊗R)+(Q⊗R) distributive
3. a⊗P = P⊗a = aP, for scalar a.
4. aP⊗bQ=abP⊗Q, for scalars a and b.
5. For conforming matrices, (P⊗Q)(R⊗X) = PR ⊗QX,
6. $(P \otimes Q)^T = P^T \otimes Q^T$, $(P \otimes Q)^H = P^H \otimes Q^H$
7. (P ⊗R) (R ⊗X) = PR ⊗QX

$$L_A \otimes L_B = \begin{pmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{pmatrix} \otimes \begin{pmatrix} b_{11} & 0 & 0 \\ b_{21} & b_{22} & 0 \\ b_{31} & b_{32} & b_{33} \end{pmatrix}$$

D. Khatri Rao Product

The KhatriRao product which an application of Kronecker Product (KP) is a column-wise product which is formerly derived by Khatri and Rao (1968) [15] and is represented below:

Given matrices $X \varepsilon R^{IxK}$ and $Y \varepsilon R^{JxK}$ Kronecker Product is denoted by X⊗Y. The result is a matrix of size (IJ)×K(IJ)×K and defined by A⊗B. The result is a matrix of size (IJ)×K(IJ)×K and defined by [15]

A⊙B=[a1⊗b1a2⊗b2…ak⊗bk]

For example, suppose I=J=2 and K=3 and you have

$$A = \begin{pmatrix} a & b & c \\ d & e & f \end{pmatrix} \qquad B = \begin{pmatrix} g & h & i \\ j & k & l \end{pmatrix}$$

$$A \odot B = \begin{pmatrix} ag & bh & ci \\ aj & bk & cl \\ dg & eh & fi \\ dj & ek & fl \end{pmatrix}$$

E. Principal Component Analysis:

Principal component analysis (PCA) is an algebraic method for interpreting numerous channels with the help of an ortho-normal projection and is used as dimension reduction. It is used to get rid of uncorrelated noise along with decomposition of trait into parts. PCA is observed in various research areassuch asimagecompression covarianceIfwe denote the matrix eigenvectorssortedaccordingteigen value by $\tilde{u}$ then PCA transformation of the data as

. $Y=\tilde{U}^T X$

The eigen vectors are called as principle components [17]. By selecting the first d rows of Y, we have projected the data from n down to d dimensions.

F. Lower and Upper (LU) Factorization*:*

The matrices can be factorized into a variety of ways with the use of Kroncecker Product [3,4], some of the factorization methods are Cholesky, LU, Schur, QR, SVD and many more. Among these methods LU factorization is chosen because it generates triangular system. The computation of LU factorization can be described for the matrices X and

Y:$X=P_X^T L_X U_X$ and $Y=P_Y^T L_Y U_Y$ then

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$$X \otimes Y = (P_X^T L_X U_X) \otimes (P_Y^T L_Y U_Y)$$

Let A,B are 3x3 matrices, for simple notation, the lower triangular system of LU factorization can be represented as

$$= \begin{pmatrix} a_{11}b_{11} & 0 & 0 & & 0\ 0\ 0 & & & 0\ 0\ 0 & & \\ a_{11}b_{21} & a_{11}b_{22} & 0 & & 0\ 0\ 0 & & & 0\ 0\ 0 & & \\ a_{11}b_{31} & a_{11}b_{32} & a_{11}b_{33} & & 0\ 0\ 0 & & & 0\ 0\ 0 & & \\ a_{21}b_{11} & 0 & 0 & a_{22}b_{11} & 0 & 0 & & 0\ 0\ 0 & & \\ a_{21}b_{21} & a_{21}b_{22} & 0 & a_{22}b_{21} & a_{22}b_{22} & 0 & & 0\ 0\ 0 & & \\ a_{21}b_{31} & a_{21}b_{32} & a_{21}b_{33} & a_{22}b_{31} & a_{22}b_{32} & a_{22}b_{33} & & 0\ 0\ 0 & & \\ a_{31}b_{11} & 0 & 0 & a_{32}b_{11} & 0 & 0 & a_{33}b_{11} & 0 & 0 & \\ a_{31}b_{21} & a_{31}b_{22} & 0 & a_{32}b_{21} & a_{32}b_{22} & 0 & a_{33}b_{21} & a_{33}b_{22} & 0 & \\ a_{31}b_{31} & a_{31}b_{32} & a_{31}b_{33} & a_{32}b_{31} & a_{32}b_{32} & a_{32}b_{33} & a_{33}b_{31} & a_{33}b_{32} & a_{33}b_{33} & \end{pmatrix}$$

G. Singular Value Decomposition (SVD):

A matrix X of dimensions M x N can be represented as [5, 11]

$X = UDV^T$

U is a column orthogonal matrix of size M x N and its columns are eigen vectors of AA^T

i.e $XX^T=UDV^TVDU^T=UD^2U^T$

V is a orthogonal matrix of size Nx N and its columns are eigen vectors of X^TX

i.e, $XX^T=VDU^TUDV^T=VD^2V^T$

D is a diagonal matrix of size N x N called singular values.

If $U = (u_1 u_2 \ldots . u_n)$ and $V = (v_1 v_2 \ldots v_n)$

then

$$X = \sum_{i=1}^{n} \sigma_i u_i v_i^T$$

H. Mean Square Error (MSE) - Decision Strategy:

In the suggested models, MSE is applied as for authentication having taken the support of selection and feature process at the validation and verification stages [5, 6].

The Mean Square Error (MSE) of an estimator $\tilde{X}$ of a parameter is the function of X defined by defined by $E(X\hat{}-X)^2$and it is denoted as $MSE_{X\hat{}}$ [5]. and it is denoted as

$$MSE(\tilde{X}) = E\left[(\tilde{X} - X)^2\right]$$

$$MSE(\tilde{X}) = Var(\tilde{X}) +$$

III. Model 1 - Feature Extraction using PCA, LU, SVD and Katri Rao Products

The suggested multimodal biometric validation system functions by normalizing the image applying Principle Component Analysis (PCA). Then decomposed image traits are aligned in the form of vector by applying vector algebra to extract the features. Extraction of the features is completed using LU factorization and then Singular Value Decomposition (SVD). In conclusion, Katri Rao product a convolution technique is used to evaluate the features. An impression of the implementation structure for the said form is depicted in Figure 1

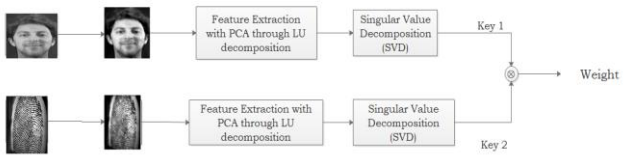

Figure 1. Framework of the implemented model

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Size of the Key (Input)	MSE - Mean Square Error		
	Completely Similar	Similar with different pose	Dissimilar
8x8	0.000000	0.040650	0.182183
16x16	0.000000	0.107721	0.136380
24x24	0.000000	0.109428	0.142879
32x32	0.000000	0.093109	0.165536
40x40	0.000000	0.115610	0.152242
48x48	0.000000	0.085422	0.195846
56x56	0.000000	0.076484	0.187258
64x64	0.000000	0.092197	0.205129

Table 1: MSE for Various sizes of Biometric traits

Taking into consideration of benchmark data sets such as AT & T, Yale and FERET, numerous experiments have been carried out. The Mean Square Error is regarded as judgment process. The investigational outcomes on the selected data are shown in Table 1 with different key sizes (input image) on similar and dissimilar poses.In the same way, testing image weights can be measured and matched up with training image weights. For assessment, MSE was considered. At this, threshold value 0.12 is taken. The proposed model working well for all key sizes

Figure 2. Graphical representation of results

IV. Model 2 – Feature Extraction using PCA, LU Factorization with Khatri Rao Product:

We presented the efficiency of multimodal biometric authentication system by conducting study into three levels such as fusion, encoding and decoding. In first stage, normalized patterns are fusioned through Principal Component Analysis (PCA), in stage two, the generated keys will be passed as inputs to the convolution kernel product for computation to increase the complexity, finally encoding and decoding process with Khatri Rao product is done. A summary of the computational process of the said work is showed in Fig. 3.

By considering standard datasets Yale, AT&T and FERET experiments are made using the proposed framework. Mean square Error (MSE) is considered for verification of the biometric patterns through the framework. Based on the error rate of MSE, the acceptance rate will be determined. From the observations of datasets for both similar and dissimilar patters of different poses using the proposed

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framework, the threshold of MSE is restricted as 0.10. In this, we are presenting three kinds of patterns with various key sizes 8x8, 16X16…64X64. The experimental results obtained presented in the Table 2. Considering the remarks of MSE, the False Acceptance Rate and False Non Acceptance Rate are calculated for different key sizes.

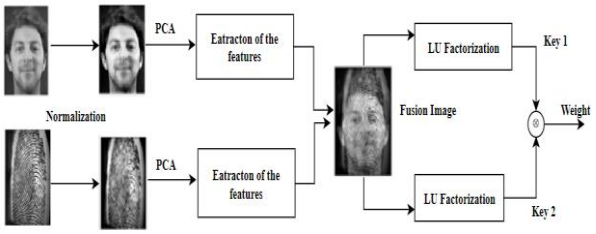

Figure 3. Framework of the implementation model 2

Size of the Key (Input)	MSE - Mean Square Error			
	Completely Similar	Similar with Different pose	Dissimilar	Dissimilar
8x8	0.000000	0.04075	0.156252	0.148052
16x16	0.000000	0.006621	0.100864	0.212347
24x24	0.000000	0.008528	0.151144	0.204937
32x32	0.000000	0.093009	0.143208	0.218194
40x40	0.000000	0.014700	0.153279	0.151572
48x48	0.000000	0.086422	0.136317	0.132662
56x56	0.000000	0.076474	0.139456	0.12681
64x64	0.000000	0.091097	0.154058	0.134501

Table 2: MSE for Various sizes of Biometr traits

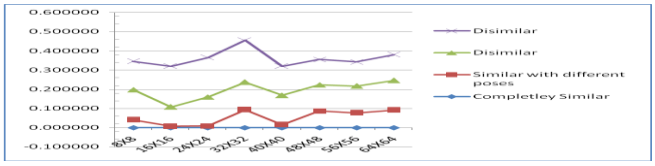

Figure 4. Graphical Representation of results

V. Conclusion:

The Convolution kernel products such as Kronecker Product and its variants like Khatri Rao playing an important part in many image analysis algorithms and removal of noisy with the use of LU factorization, PCA and SVD since Gaussian transformation eliminates noise. We presented a multi-model biometric authentication using Feature Extraction and Image Analysis. The authentication uses kernel methods like LU, SVD and Applications of Kronecker Algebra that were experimented with

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popular benchmark datasets like Yale and AT&T, FERET data sets that has shown good results for verification of the biometric patterns through the framework models. These methods can also be extended to use with deep and machine learning algorithms to obtain good results and is considered as the next course of activity

REFERENCES

[1] Vaclav Matyas, Zdenek Riha, "Biometric Authentication —Security and Usability", http://www.fi.muni.cz/usr/matyas/K. Jain, A. Ross, S. Prabhakar, S. An Introduction to Biometric Recognition. IEEE Trans. Circuits Syst. Video Technol., 14, 4-20, 2004.
[2] Y Suresh, "Image Analysis using LU, SVD and Kronecker Algebra in Multimodal Biometric Authentication System" , International Journal of Research in Advent Technology, Vol. 7, Issue. 3, 2019, pp. 1319-1322.
[3] Y. Suresh, K. Pavan Kumar, PESN Krishna Prasad, "Feature Selection in Multimodal Authentication Using LU Factorization with CSEAM Model", International Journal of Computer Science and Application (IJCSA), Vol.5, No.1, February 2015.
[4] Lester Lipsky and Appie van deLiefvoort, Transformations of the Kronecker Product of Identical Servers to Reduced Product Space, 1995.
[5] Wolfgang Hackbusch, Boris N. Khoromskij, Hierarchical Tensor-Product Approximations, 1-26.
[6] V. Ghattis, A.G. Bors and I. Pitas, " Multimodal decision level fusion for person authentication," IEEE Trans. Systems, Man and Cybernatics, vol. 29, no. 6, pp, 674-680, Nov. 1999.
[7] A.K. Jain and Ross, "Learning user specific parameters in multibiometric system," Proc. Int. Conf. Image Processing (ICIP), pp. 57-60,2002.
[8] Y. Suresh, K. Pavan Kumar, PESN Krishna Prasad, "Pattern Recognition Using Context Dependent Memory Model (CDMM) In Multimodal Authentication System", International Journal in Foundations of Computer Science & Technology (IJFCST), Vol.5, No.1, PP.47-57, January 2015.
[9] Huamin Zhang and Feng Ding On the Kronecker Products and Their Applications, Hindawi Publishing Corporation Journal of Applied Mathematics Volume 2013, http://dx.doi.org/10.1155/2013/296185
[10] Sanjekar, Prit, Patil, Jayantrao. (2013). An Overview of Multimodal Biometrics. Signal[Image Processing: An International Journal (SIPIJ) Vol. 4. 57-64. 10.5121/sipij.2013.4105.
[11] Fawaz Alsadde, " A Study of Neural Network and its Properties of Training and Adaptability in Enhancing Accuracy in Multimodal Biometric Scenario", Information Technology Journal, 9(1):188-191,2010.Liu, Shuangzhe & TRENKLER, OTZ. (2008). Hadamard, Khatri-Rao, Kronecker and other matrix products. International Journal of Information & Systems Sciences. 4.
[12] H Benaliouche, M Touahria, "Comparative Study of Multimodal Biometric Recognition by Fusion of Iris and Fingerprint", Recent Advances in Information Technology, https://doi.org/10.1155/2014/829369
[13] Y Gon Kim, K Yong Shin, E Chul Lee, K Ryoung Park, "Multimodal Biometric System Based on theRecognitionofFacandBoIrises" Internationl Journal of Advanced Robotic Systems, Volume: 9 issue: 3, 2012, https://doi.org/10.5772/50869.
[14] Chhaya Sunil Khandelwal, Ranjan Maheshewari, U.B. Shinde, "Review Paper on Applications of Principal Component Analysis in Multimodal Biometrics System", Procedia Computer Science, Volume 92, 2016, Pages 481-486, ISSN 1877-0509, https://doi.org/10.1016/j.procs.2016.07.371.
[15] S. K. Choudhary and A. K. Naik, "Multimodal Biometric Authentication with Secured Templates — A Review," 2019 3rd International Conference on Trends in Electronics and Informatics (ICOEI), 2019, pp. 1062-1069, doi: 10.1109/ICOEI.2019.8862563.

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