ISSN(Online) : 2320-9801
ISSN (Print) : 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2016

Usage of Finger Knuckle as Effective Supporting Biometric: A Literature Survey

Sampada H. Raut[1], Vishal B. Raskar[2]

ME Student, Dept. of Electronics & Telecommunication, JSPM's Imperial College of Engineering & Research, SavitribaiPhule Pune University, Pune, India [1]

Assistant Professor, Dept. of Electronics & Telecommunication, JSPM's Imperial College of Engineering & Research, SavitribaiPhule Pune University, Pune, India[2]

ABSTRACT: Biometrics based personal identification had been the quite prevalent research area among the engineers recently. Although it was initially employed for personal identification, numerous biometrics applications are extensively being used for personal authentication purposes very commonly now days. Iris recognition or finger prints recognitions are the most predominantly used biometrics example. However, such kinds of biometrics make more sense where subject voluntarily involves in the identification process. On the other hand, many of situations e.g. fact finding for a legal application, where it is needed to precisely recognize a person without a prior cooperation agreement, most of the common biometrics fail to prove their application. The system then needs to look for additional commonly evident biometrics. Human knuckle surfaces are the most suitable ones in such scenarios. There had been many of notable works recorded into literature which prove the establishment of finger knuckles as the best performing biometric. The present paper tries to put forward a detailed and focused literature survey of techniques using knuckle surfaces as either the effective biometrics for personal identification or the supportive one for results improvisation.With insipient progress in machine learning algorithms, modern day engineers are taking advantage of superior machine learning algorithm which continuously providing increasing trend of accurate personal identifications as this review shows.

KEYWORDS: Finger Knuckles, Biometrics, Principal Component Analysis, Constant Nearest Neighbour Search

I. INTRODUCTION

At the earliest like 500 B.C. fingerprints on clay slabs were used as the authorising signatures of a trader as found recorded in Babylonian trade records. This could have been the firsts of known use of biometrics in the human history. However, it can be very well said that the mankind learnt to make use of biometrics much earlier, perhaps from the age of first human generations. That time primarily the facial identification is practiced for personal identity. As the human society grew, so the population went high. Humans started living small clusters doing trades across. And the facial identification didn't make much sense for personal authentication. Then they developed the signature system. A ring or stamps were the initial specialized instruments but when it came to generic purpose and absolute true authentication fingerprints became the biometric solution to identification.

The word biometrics originated from Greek, where bio meant lively and metric meant measure. Thus there are some generic rules for biometrics. These are universality, permanence and measurability. Firstly, it is its universality in nature. Universality means every normal human being must possess the biometric. Like the commonly used biometrics, e.g. iris, fingerprints, ear surfaces etc. are identified to be with any normal human personality. Secondly, the permanence means the time invariance of the human biometric feature. For example, the fingerprints do not change over the time or age of the person. So one can use them to identify or authenticate irrespective of age of the subject. Lastly, it is the measurability of the biometric. Measurability means the biometric can be extracted by means of a system, in a form of information which can be further processed, compared or stored as and when needed. For example the personal iris coloured structure can be verified with the stored ones.

ISSN(Online) : 2320-9801
ISSN (Print) : 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2016

With the advent of technology and science, one can see the pattern of different physical traits being used as biometrics. More and more advanced technologies became available to measure some of the complex biometrics. Like ear patterns, thumbnails of fingerprints, iris patterns could be processed with specialized cameras and stored in form of digitalized information. Also, there is multitude of situations where the biometrics made their use. For authentication in banks, trades, accessing secure areas or workplaces, legal documents, countrywide citizen databases, passports andimmigrations, law and court related, cybernetics, criminals databases, etc.

Not all the time the biometrics are collected or processed for comparisons in voluntarily of the subject. In many of the situations, one has to rely on evidential proofs. Like a criminal may not leave or show his/her fingerprints at the crime scene. Similarly, from the surveillance cameras may not always show you the faces or iris. Moreover, the hands as mostly captured by cameras will show their backsides in action and not the palm side. In such scenarios, supportive biometric can be of help to a great deal. For the most relevant idea, the finger knuckle surfaces are identified as the strong supportive biometrics. The knuckle surface at the back of finger is formed at the joints of small finger bones. The skin texture and the specified curves and lines of the knuckle surfaces are the distinctive feature across human beings. The literature works had shown that the finger knuckle surfaces satisfies the basic requirements of a biometrics, being their universality in humans of all cultures and in all geographical regions, being unique to beholder and quite well measurable. In most of the scenarios, the knuckles based biometric system won't require much of subject's cooperation. These are most likely to be captured by cameras in most common hand gestures and actions.

Basically, authors had been putting an effort on development of an automatic system to use knuckle biometrics based on principal component analysis and K-nearest neighbour's algorithm. During their efforts a detailed literature study was conducted to know-how of such state of the art systems and their performances with individual pros and cons. Most of the best efforts and developments are summarized in this paper with intention to create a useful literature survey report available to newer researchers embarking their work in this field. Moreover, apart from fresher researchers the report can be helpful for the medical, engineering or legal practitioners.

II. RELATED WORK

This section forms the core soul of this article and intended to be most lucid and generic in providing the ideas in brief of most of the chosen published articles in literature on the systems developed for finger knuckles biometrics. In order to make it reader friendly and improve its useful effectiveness the section is managed in four different subsections as follows.

A. *Hand Based Biometric Systems*

In 2003, Zhang et al. [1] have developed an online palmprint identificationsystem for real-time personal identification by applying anovel CCD camera-based palmprint device to capture thepalmprint images. As they described a preprocessing algorithm extracted acentral area from a palmprint image for feature extraction to represent a low-resolution palmprint image and match different palm print images. They extended the use of 2D Gaborphase coding to represent a palmprint image using itstexture feature, and apply a normalized hamming distancefor the matching measurement. Using this representation,the total size of a palmprint feature and its mask is reducedto 384 bytes. In their palmprint database of 7,752 palmprintimages from 386 different palms, they could achieve highgenuine (98 percent) and low false acceptance (0.04 percent)verification rates, and its equal error rate is 0.6 percent,which is comparable with most of state of the art palmprint recognitionapproaches.

Similarly in 2007, Hennings-Yeomans et al. [2] proposed a palm print classification algorithm. They made use of multiple correlation filters per class. Each of correlation filters are two-class classifiers that produce a sharp peak when filtering a sample of their class and a noisy output. They trained the filters for a palm at different locations, where the palmprint region has a high degree of line content, for each class. With the use of a line detection procedure and a simple line energy measure, they achieved to score any region of the palm using trained filters for each class based on ranked database. Making use of an enhanced palmprint segmentation algorithm, their proposed classifier achieved an average equal error rate of 1.12 times10-4% on a large database of 385 classes using multiple filters of size 64 times 64 pixels.

Kumar and Zhang [3] in their paper in 2006, proposed a new bimodal biometric system using feature-level fusion of hand shape and palm texture. The proposed combination was of significance since both the palmprint and hand-shape

ISSN(Online) : 2320-9801
ISSN (Print) : 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2016

images are proposed to be extracted from the single hand image acquired from a digital camera. They investigated several new hand-shape features that could be used to represent the hand shape and improve the performance. They demonstrated the new approach for palmprint recognition using discrete cosine transform coefficients, which could be directly obtained from the camera hardware. Till then, none of the prior work on hand-shape or palmprint recognition had given any attention on the critical issue of feature selection. Their experimental results demonstrated that while majority of palmprint or hand-shape features were useful in predicting the subjects personal identity, only a small subset of these features were necessary in practice for building an accurate model for identification. The comparison and combination of proposed features was evaluated on the diverse classification schemes; naive Bayes (normal, estimated, multinomial), decision trees, k-NN, SVM, and FFN.

In the same year of 2006, Malassiotis et al. [4] also proposed a different approach for biometricauthentication that was based on measurements of the 3-D handgeometry using a real-time low-cost 3-D sensor. They had demonstrated the ability of the proposed algorithms working robustly in relatively unconstrained conditions. Moreover, their resultsobtained on a relatively large database indicated that performance was not sacrificed. Although the error rates achieved were higher thanthose required in security applications, there were several otheremerging applications such as personalization of services andattendance control that might benefit from the unobtrusive userauthentication achieved by their proposed system. They also added that if their proposed system would be combined with other authenticationmodalities such as face recognition, one can expect superior performance of the multimodal system since 3-Dhand geometry was not affected by variations in illumination, age,obstructions, etc. In particular the same 3-D sensor could also be usedto capture face and hand images and therefore their proposedtechnique was ideal for fusion with 3-D face biometrics as reported in similar other literature. This was expected to lead to a low-cost solution offering highlyreliable authentication without sacrificing user convenience.

It would be noteworthy to mention about one of the recent time efforts by Wang et al. [5] in 2008, who investigated unimodal analysis of palmprint and palm vein for person recognition. One of the problems with unimodality was that the unimodal biometric was less accurate and vulnerable to spoofing, as the data can be imitated or forged. In their paper Wang et al. presented a multimodal personal identification system using palmprint and palm vein images with their fusion applied at the image level. The palmprint and palm vein images were fused by edge-preserving and contrast-enhancing wavelet fusion method. In this method the modified multiscale edges of the palmprint and palm vein images were combined. They developed a fusion rule that enhanced the discriminatory information in the images. They came up with a novel palm representation method which they termed as “Laplacianpalm”.It was extracted from the fused images by the locality preserving projections (LPP). Unlike the Eigenpalm approach, the “Laplacianpalm” finds an embedding that preserves local information and yields a palm space that best detects the essential manifold structure. Eventually, they compared their proposed “Laplacianpalm” approach with the Fisherpalm and Eigenpalm methods on a large data set. As they had presented the experimental results showed that their proposed “Laplacianpalm” approach provided a better representation achieving lower error rates in palm recognition.

Most of the above summarized and other similar literature presented efforts which actually proposed the systems which required user cooperation. In such systems not always user or the subjects felt comfortable to touch their hands or fingers within the system sensors. Mostly, the small children and elderly persons feel uneasy with such systems. Besides as also narrated in the introductory section, the camera based evidences are not very easily process able with these systems. Many of the systems are slow and time consuming and prove inefficient while dealing with high speed online or live video feed based biometric identifications.

B. *Systems Using Finger Knuckle as Biometric*

Even before to look at the systems using finger knuckles as effective biometric, let’s seek the baseline information regarding the finger knuckles. As illustrated in Fig. 1, the fingers are connected with palm bone structure through means of phalanx. These small bones i.e. phalanges (plural to phalanx) constitute the fingers. The fingers bend at the inter-phalangeal joints. The back surface of the inter-phalangeal joints as it appears with texture and lines is the very knuckle surface used as the biometric.

In 2005, Woodard and Flynn [6] presented a novel approach for personal identification, which utilizes finger surface features, primarily the knuckles as a biometric identifier. This was first of its kind of system utilizing finger knuckle surfaces as the biometric. They calculated the curvature-based surface representation, shape index, for the index, middle, and ring fingers using dense range data images of the hand. This representation was used for comparisons to

ISSN(Online) : 2320-9801
ISSN (Print) : 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2016

determine subject similarity. Their experiments involved the use of a large data set of range images collected over time. They also examined the performance of individual finger surfaces as a biometric identifier as well as the performance when using the three finger surfaces in conjunction. The results of experiments indicated that this approach performed well for this system with knuckle biometric.

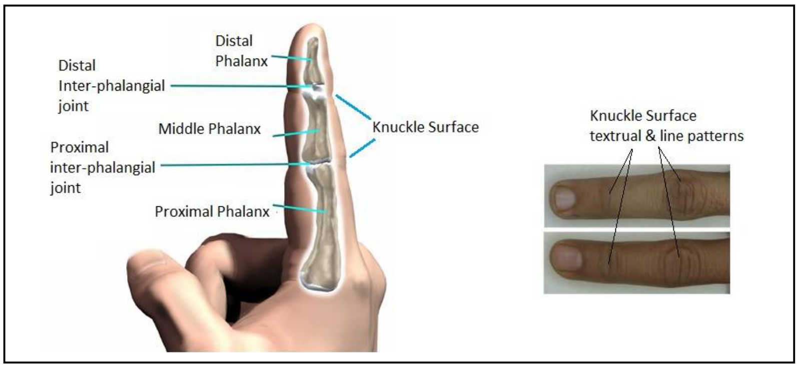

Fig.1. Illustration of finger anatomy and knuckle surfaces

In another parallel effort on using knuckle as biometric identifier it would be worthwhile mentioning the works by Kumar and Ravikanth [7][8]. Firstly in 2007 [7] and then in 2009 [8] tried to present their results on their developed knuckle based biometric system as they tested it out with a large subject datasets. They investigated the system based on texture of the hand knuckles. The texture pattern generally produced by the finger knuckle bending is highly unique and makes the surface a distinctive biometric identifier. They tried to combine it with hand geometry biometric system to seek the performance improvement using two biometric. Hand geometry features were acquired from the same image, at the same time and integrated to improve the performance of the system. The finger back surface images from each of the users were used to extract scale, translation and rotational invariant knuckle images. Their proposed system, especially on the peg-free and non-contact imaging setup, achieved promising results when tested over a database of 105 users as they reported in the article.

Further in 2009, Zhang et al. [9] presented a new approach to online personal authentication using fingerknuckle-print (FKP), which has distinctive line features. They claimed to have developed a cost-effective FKP system,including a novel image acquisition device and the associated data processing algorithms. To efficiently match the FKPs, they proposed a BandLimited Phase-Only Correlation (BLPOC) basedFKP matching method. They conducted extensive experiments and demonstrated the efficiency and effectiveness of their proposed technique. They commented that comparing with other existing finger back surfacebased systems, their proposed FKP authentication has merits of high accuracy, highspeed, small size and cost-effective. Unlike other systems as developed by this time which used to capture the entire hand camera image and then extract out the knuckle images, this system directly captures the knuckles area image only.

In 2006, Sricharan et al. [10]investigated the possibility of using the knuckle as a biometric trait for user authentication. They as well extracted the knuckle regions from the hand images and used correlation methods for the purpose of verification. Their experimental results on a data set of 125 people showed that the finger knuckle surfaces area viable biometric trait, which can be used as an alternative to finger and palm prints or in conjunction with them.

Very recently in 2012, Choras and Kozik [11], presented their developments in palmprint segmentation and feature extraction for human identification are presented. Moreover, they also presented a new approach to knuckle biometrics. They showed that both palmprint and knuckles features may be considered as very promising biometric modalities which can be used in contactless human identification systems. As they illustrated, their goal was to propose efficient algorithm that could run on mobile devices. However, in the paper they showed the results for palmprint and knuckles biometrics, but on separate databases. But now they working on creating multimodal hand–palm–knuckle database acquired by mobile phones cameras in unrestricted (real-life) conditions. They claimed that their methods can be used

ISSN(Online) : 2320-9801
ISSN (Print) : 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2016

in mobile biometrics scenario since mobile end-terminals portfolio has exploded with devices providing greater functionality and usability with more processing power on board. It was estimated that by 2015 all the sold mobile handsets will be “smart” which more of the truth looks now days.They also forecasted that biometric human identification using contactless unsupervised images would very soon become important application.

On the similar lines with Zhang et al. [9] but in 2011, Aoyama et al. [12] proposed a Finger-Knuckle-Print (FKP) recognition algorithm using Band-LimitedPhase-Only Correlation (BLPOC)-based local block matching. They provided that the phase informationobtained from 2D Discrete Fourier Transform (DFT) of images contains important informationof image representation. The phase-based image matching, especially BLPOC-basedimage matching,was successfully applied to image recognition tasks for biometric recognitionapplications. Their proposed algorithm used to correct the globaland local deformation between FKP images using phase-based correspondencematching and the BLPOC-based local block matching, respectively, to calculate the matching score. Their experimental evaluationusing thePolyU FKP database demonstrated the efficient recognition performance of their proposed algorithm compared with the state-of-the-art conventional algorithms.

Kumar [13] in a conference in 2012 on biometrics theory and application, iterated that biometric identification using finger knuckle imaging has generated lot of promises with interesting applications in forensics and remote biometrics. Prior efforts in the biometrics literature have only investigated the `major' finger knuckle patterns that are formed on the finger surface joining proximal phalanx and middle phalanx bones. However, he investigated the possible use of `minor' finger knuckle patterns which are formed on the finger surface joining distal phalanx and middle phalanx bones. He commented that the `minor' or `upper' finger knuckle patterns could either be used as independent biometric patterns or employed to improve the performance from the major finger knuckle patterns. He also investigated a completely automated approach for the `minor' finger knuckle identification by developing steps of region of interest segmentation, image normalization, enhancement and robust matching to accommodate image variations. He had presented comparative experimental results for matching the normalized `minor' finger knuckle images using LBP, ILBP and 1D log Gabor filter. He demonstrated that the efforts to develop automated `minor' finger knuckle patterns achieve promising results, with 1.04% equal error rate on the database of 202 subjects, and illustrated its simultaneous use to improve the performance for conventional finger knuckle identification.

C. *Numerical Techniques Involved*

It is also necessary to have a look at the machine learning techniques or algorithms generally being used for finger knuckle based biometrics. As the literature review suggests one can see a varied used of techniques like Canny and Sober edge detectors, Local binary Patterns (LBP), Gabor filters, Principal Component Analysis etc. In this section one shall have a brief understanding to these techniques philosophies.

As Li and Jain [14] had mentioned in his book of encyclopedia of biometrics, the LBP texture analysis operator introduced by Oljala et al. [15][16][17] is defined as a gray scale invariant texture measure, derived from a general definition of texture in a local neighborhood. It is a powerful mean of texture description and among its properties in real world applications are, it discriminative powers, computational simplicity, and tolerance against monotonic gray scale changes. The original LBP operator forms labels for the image pixels by thresholding the 3 X 3 neighborhood of each pixel with the central value and considering the result as a binary number. The histogram of 2^8 = 256 different labels can then be used as a texture descriptor.

Sobel detection refers to computing the gradient magnitude of an image using 3x3 filters. Where "gradient magnitude" is, for each a pixel, a number giving the greatest rate of change in light intensity in the direction where intensity is changing fastest.Canny edge detection goes a bit further by removing speckle noise with a low pass filter first, then applying a Sobel filter, and then doing non-maximum suppression to pick out the best pixel for edges when there are multiple possibilities in a local neighborhood. That's a simplification, but basically it’s smarter than just applying a threshold to a Sobel filter, but it is still fairly low level processing."Edge detection" could refer to either of the above, or to many modern edge detection algorithms that are much more sophisticated than either of the above. For example there are edge detectors that have some success at finding edges between two textured regions while ignoring the edges in the textures themselves. There are edge detectors that are more global in scope in that they try to find edges between regions of homogeneous color or texture. Likewise, another global algorithm looks for edges that follow smooth contours even when parts of those contours are weak or obscured. A recent paper based edge detection on the statistics of color co-occurrence between adjacent pixels. I am too lazy to write out all the references.

ISSN(Online) : 2320-9801
ISSN (Print) : 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2016

Chen et al. [18] in 2002 on their paper on implication of principal component analysis (PCA) in biometric application mentioned that PCA has been widely used for analyzing the statistics of data. While applied to biometrics as a classification scheme, PCA faces certain challenges. They presented a number of modifications to PCA in order to meet these challenges. Using face recognition as an example, they showed how eigenflow, PCA applied to optimal flow, enabled them to measure the difference between two images while allowing expression changes and registration error. They also showed how PCA could be updated to model time-varying statistics. And that PCA could be used to model the surface reflectance of human faces and reduce illumination variation that normally found to defeats most existing face recognition algorithms. Concluding they presented distinguishing component analysis (DCA) and applied it to multimodal biometric authentication.

III. CONCLUSION

The paper discussed the introductory of human biometrics in great details. The baseline idea of the paper is to summarize the key literature recorded efforts making use of finger knuckle surfaces as effective biometric. As the literature actually shows the finger knuckle surface can be a strong individual biometric to be implanted for individual authentication systems. Else, the knuckle surface can also be used in collaboration with other biometrics to improve the generalized efficiency of the system. Many researchers had put the efforts in developing the biometric systems based on knuckles with primary intention to avoid the not so comfortable finger touch with the system or to avoid the much need user cooperation. Also, the paper tries to focus a little on the adavanced numerical algorithms commonly used in the knuckle based biometric systems.

REFERENCES

1. D. Zhang, W. K. Kong, J. You, and M. Wong, “On-line palm print identification,” IEEE Trans. Pattern Analysis and Machine Intelligence, vol. 25, pp. 1041-1050, Sep. 2003.
2. P. H. Hennings-Yeomans, B. V. K. Kumar, and M. Savvides, “Palm print classification using multiple advanced correlation filters and palm-specific segmentation,” IEEE Trans. Information Forensics and Security, vol. 2, no. 3, pp. 613-622, Sep. 2007.
3. A. Kumar and D. Zhang, “Personal recognition using hand shape and texture”, IEEE Trans. Image Processing, vol. 15, no. 8, pp. 2454-2461, 2006.
4. S. Malassiotis, N. Aifanti, and M. G. Strintzis, “Personal Authentication using 3-D finger geometry”, IEEE Trans. Information Forensics and Security, vol.1, no.1, pp.12-21, Mar. 2006.
5. J.-G. Wang, W.-Y. Yau, A. Suwandy, and E. Sung, “Person recognition by fusing palm print and palm vein images based on “Lapacianpalm” representation,” Pattern Recognition, vol. 41, pp. 1531-1544, 2008.
6. D. L. Woodard, P. J. Flynn, “Finger surface as a biometric identifier”, Computer Vision and Image Understanding, pp. 357-384, vol. 100, Aug. 2005.
7. Ravikanth, C., Kumar, A., “Biometric authentication using finger-back surface”. In: Proc.CVPR, pp. 1–6. 2007.
8. Kumar, A., Ravikanth, C., “Personal authentication using finger knuckle surface,” IEEE Trans. Information Forensics and Security 4(1), 98–109. 2009.
9. Lin Zhang, Lei Zhang and David Zhang, “Finger-Knuckle-Print Verification Based on Band-Limited Phase-Only Correlation,” Proc. CAIP '09 Proceedings of the 13th International Conference on Computer Analysis of Images and Patterns, Pages 141-148. 2009.
10. K. Sricharan, A. Reddy, and A. G. Ramakrishnan, “Knuckle based hand correlation for user verification,” Proc. SPIE, vol. 6202, p. 62020X, Apr. 2006.
11. M. Chora´ s and R. Kozik, “Contactless palmprint and knuckle biometrics for mobile devices,” Pattern Anal. Applicat., vol. 1, no. 15, pp. 73–85, 2012.
12. S. Aoyama, K. Ito, and T. Aoki, “Finger-knuckle-print recognition using BLPOC-based local block matching,” in Proc. ACPR, Nov. 2011, pp. 525–529.
13. A. Kumar, “Can we use minor finger knuckle images to identify humans?” in Proc. IEEE 5th BTAS, Sep. 2012, pp. 55–60.
14. Stan Li and Anil Jain, “Encyclopedia of biometrics,” Springer Reference Series, 2015.
15. Ojala, T., Pietikäinen, M. and Harwood, D., “A Comparative Study of Texture Measures with Classification Based on Feature Distributions,” Pattern Recognition 19(3):51-59, 1996.
16. Ojala, T. and Pietikäinen, M., “Unsupervised Texture Segmentation Using Feature Distributions,” Pattern Recognition 32:477-486. 1999.
17. Ojala, T., Pietikäinen, M. and Mäenpää, T., “Multi Resolution Gray-scale and Rotation Invariant Texture Classification with Local Binary Patterns,” IEEE Trans. Pattern Analysis and Machine Intelligence 24(7): 971-987. 2002.
18. T. Chen, Y. Jessie Hsu, X. Liu, W. Zhang, “Principle component analysis and its variants for biometrics,” Proceedings. International Conference on Image Processing. Vol. 1, pp; I-61 to I-64. 2002.