International Journal of Engineering & Technology, 7 (1.2) (2018) 9-14

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Survey on finger-vein segmentation and authentication

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Abstract

Exploding growth in the field of electronic information technology, the finger vein authentication technique plays a vibrant role for personal identification and verification. In recent era, this technique is gaining popularity, as it provides a high security and convenience approach for personal authentication. Vein biometrics is an emerging methodologycomparing to other systems, due to its strengths of low forgery risk, aliveness detection and stableness over long period of time. Literatures published based on different techniques used forand authentication process are described and evaluated in this paper. These processes hadgained an outstanding promise in variety of applications and much attention among researchers to provide combine accuracy, universality and cost efficiency. This paper in brief, reviews various approaches used for finger vein segmentation and feature extraction. The reviews are based on finger vein basic principles, image acquisition methodology, pre-processing functions, segmentation, feature extraction,classification, matching and identification procedures, which are analyzed scientifically, thoroughly and comprehensively.Based on the analysis, the ideal process and procedure is identified, which will be an idyllic solution for finger vein authentication.

1. Introduction

Application of biometric technology plays a key role in authentication systems. It verifies the identity of people based on their biometrics features and its properties [1]. Some of the most important properties are - Uniqueness, Universality, Collectability, Performance, Acceptability, Circumvention and Permanence. Finger veins because of this natural property, it is hard to forge and caricature them, further it also assures the aliveness of person, whose biometrics is being proved.
The finger vein pattern can only be taken from a live body and these patterns of most people remain unchanged despite ageing and cannot be changed even by surgery. The condition of the epidermis has no effect on the result of vein detection. Hand and finger vein detection methods do not have any known negative effects on body health. It is impossible to steal or copy the biometric patterns by photography or video recording, which makes it extremely difficult to duplicate the biometric data. These desirable properties make vein recognition a highly reliable method [2].
Common steps for Finger vein pattern authentication process are:Data Acquisition, Preprocessing Feature Extraction and Classification.

1.1. Image acquisition

In the process of image acquisition, vein images are captured using infrared scanner. Captured images are affected by influence of blood pressure of veins, body temperature, and environment circumstances which needs to be preprocessed for its accuracy.
Image acquisition is of two type i.e. off-line and online. On-line images are the images which are taken in real time and off-line images are taken from already created database. The images in real time can be obtained by normal web camera or by designing a finger-vein imaging device based on light transmission for more distinct imaging.
For on-line images there are two ways of finger vein image acquisition, i.e., light reflection and light transmission method [3]. The main difference between these methods, is the position of near-infrared light. In light reflection method near-infrared light is placed in finger palmer side and finger vein pattern is captured by the reflected light from finger palmer surface. Whereas in light transmission method, near-infrared light is placed in finger dorsal side and light will penetrate finger. While comparing with light reflection method, light transmission method can capture high contrast image, that's why most of the image acquisition devices employ this method.

1.2. Preprocessing

A number of pre-processing tasks are to be performed for the application of image-based biometric systems. This helps to enhance the image quality and some of these tasks are contrast, brightness, edge information, noise removal, sharpen image, etc. Furthermore, to produce a better quality of image which will be used during later stage as an input in order to assure that more relevant information can be detected for authentication.
Better quality of image will help to gain better accuracy rate in biometric authentication system. Initially the finger vein image pre-processing involves, image segmentation and alignment, image denoising i.e. noise removal, image ROI(Region of Interest) detection, image enhancement, image size normalization [4].
In image segmentation the actual image is separated from its background and also noise is removed up to some extent but it is quite difficult to extract precise details of the vein pattern because of irregular noise and shades around the finger vein. Threshold image method is used by which computes creates thresholds for every pixel and creates a binary image i.e. image with only black or white colour. The most essential part of thisoperation will be

the selection of a single threshold value which is the peak value of the image and called binarization.

1.3. Segmentation

The image acquired during image acquisition has other information besides the finger vein region. Image segmentation is the process of separating or grouping an image into different parts. These parts normally correspond to something that humans can easily separate and view as individual objects. Computers have no means of intelligently recognizing objects, hence many different methods have been developed in order to segment images. The segmentation process in based on various features found in the image. This might be color information that is used to create histograms, or information about the pixels that indicate edges or boundaries or texture information.

1.4. Alignment

The main problem in the process of taking images is trying to keep the subject’s hand in place without movement. While capturing the images, there is a possibility that the user may tilt his/her finger a little to the right or left. As a solution to this problem, either keep a tube-like structure in the hardware or align the images in the software algorithm. The edges are detected and the image is rotated such that the detected edges are now horizontal.

1.5. Image enhancement

Image enhancement operation improves the quality of the image. It is used to improve the image contrast, brightness characteristics, reduce its noise content, and/or sharpen its details. This step is used to highlight the finger vein network pattern in order to increase the accuracy of the algorithm.

1.6. Image normalization

The position of fingers usually varies according to different finger-vein images. So it is necessary to normalize the finger-vein images before the process of feature extraction and matching. To achieve high accuracy for finger vein authentication algorithm, the original image is normalized into smaller size i.e. resized to 1/4th of the original size. This is the optimum scaling factor, which is obtained from the experiment of the vein image database for various scaling factor. Moreover, processing speed is also reduced with the scaling factor. It is also advised to divide the image with the maximum intensity level of that image.

1.7. ROI extraction

In the finger images, there are many unwanted regions (that cannot be taken for analysis) which is to be removed by choosing the interested area in that image. The image having black unwanted background.Will reduce the accuracy of the algorithm. Therefore, the original image is extracted from the undesired background. A special algorithm is developed to extract the finger vein image from the background. The useful area is said to be “Region of Interest (ROI)”.

1.8. Feature extraction

Feature extraction is a special form of dimensionality reduction that transforms input data into the set of features. Variety of algorithms are used for this process also filters such as median filter, Gabor filter, SIFT, minutiae, statistical measures, local binary pattern, skeleton method are used for feature extraction to extract the features of vein without noise and deformation. To develop highly accurate personal identification systems, Finger-vein patterns should be extracted precisely from the captured images, and the process must be executed speedily in order to satisfy requirements.

1.9. Classification

Fein Vein classification is assigning pixels in the image to categories or classes of interest based on learning techniques and features. Types of learning technique are - Supervised Learning and Unsupervised learning. In Supervised Learning process is designed to form a mapping from one set of variables (data) to another set of variables (information classes) and monitoring involved in the learning process. The classifier has the advantage of an analyst or domain knowledge using which the classifier can be guided to learn the relationship between the data and the classes. The number of classes, prototype pixels for each class can be identified using this prior knowledge.
Unsupervised learning happens without a monitor and Exploration of the data space to discover the scientific laws underlying the data distribution. When access to domain knowledge or the experience of an analyst is missing, the data can still be analyzed by numerical exploration, whereby the data are grouped into subsets or clusters based on statistical similarity.
Supervised classification generally performs better than unsupervised classification If good quality training data is available unsupervised classifiersis used to carry out preliminary analysis of data prior to supervised classification. In Features classification method feature are attributes of the data elements based on which the elements are assigned to various classes.

1.10. Matching

Matching is one of the important stage in finger vein identification. After features are extracted from the vein image the matching stage measures the similarity or dissimilarity between the input finger vein image features and the previously enrolled ones in the database.

2. Survey on finger vein segmentation

Fernando C. Monteiro [5] proposed a new image segmentation method comprising edge based information with the help of spectral method and morphological algorithm of watershed. Firstly, they reduce the noise from image using bilateral filter as a preprocessing step, secondly, region merging is used to perform preliminary segmentation, region similarity is generated and then graph based region grouping is perform using Multi-class Normalized Cut method[6]. This technique has outperformed other methods and produces better results but the computational complexity is higher.
R. V. Patil [7] claims that if the number of clusters is estimated in accurate manner, K-means image segmentation will provide better results. A new method based on edge detection to estimate number of clusters was proposed. Phase congruency is used to detect the edges and these are used to find clusters. Threshold and Euclidean distance is used in order to make clusters. K-means is used to find the final segmentation of image. Experiments are performed on nine different images and results shows that number of clusters is accurate and optimal.
Weihong Cui Yi Zhang [8] proposed an edge based auto threshold select method to generate multi-scale image segmentation. Band weight and NDVI (Normalized Difference Vegetation Index) is used to calculate edge weight. Edge based Threshold method is used to perform image segmentation. Experiments were performed on multi-scale resolution images, i.e., Quick-bird multispectral images and results showed that this method maintain the object information and object boundaries while segmenting the image.
Anna Fabijańska [9] introduced a new method using Variance Filter for edge detection in image segmentation process. This method identifies the edge position using Variance Filter. Sobel Gradient filter with K-means is also used to extract the edges and compared with the proposed technique. The effect of filtering window size on determining edges is also discussed and it is found that if the 9×9 window is used to extract edges then edges are

accurately matching the shape of object in the image. In case of larger detailed images, a small filtering window is preferred.

Mohammed J. Islam [10] found that Computer Vision is a best solution for real time inspection of capsules in pharmaceutical industry. Author had developed a system for quality inspection using edge based image segmentation techniques. They used Sobel Edge Detector in order to detect edges with noise-suppression property. After edge detection, Otsu Thresholding technique is used for localization of background and foreground pixels. Experiments are conducted and results are compared with NN-based segmentation technique building Visual C++. The Results outperform NN technique on the basis of accuracy with processing time difference of 10 ms.

D. Barbosa [11] proposed a new image segmentation technique which joins the edge and region based information with spectral method using Morphological Watershed algorithms.Initially noise filter is used with Magnitude Gradient during pre-processing stage and subsequently pre-segmentation is done using region merging. Further region similarity graph is generated and finally segmentation is performed using Multi Class Normalized Cut. This method is compared with Mean Shift, MNCUT, and JSEG using natural images. Proposed technique overcomes Spectral Clustering method.

Gang Chen [12] observed that that fast extraction of object information from a given image is a problem for real time image processing. Also the region based methods are time consuming and not give effective segmentation. A new region based application was proposed considering Least Square method in order to detect objects sharply by using weight matrix which also takes care of the local information into account. The usage of Least Square method provides optimal and fast segmentation. While comparing with other methods, this one can extract the features more accurately and effectively.

Zhen Hua, Yewei Li [13] proposed a new image segmentation method based on improved visual attention and region growing approach. In this method, the gray values and edges of input image are extracted using Gabor filter and Guass-Laplace filters. Then ANN method is used to extract the region of interest. Based on the experiments conducted on natural scene images, it is found that their algorithm not only segmented the image perfectly but also found the salience edges which others methods can't.

Tiancan Mei [14] claims that Markov random field (MRF) is suffered from lack of handling the large range of interaction. In order to overcome this a new supervised image segmentation method - Region based Multi-scale segmentation method was proposed. Natural scene images are used as a dataset and by using region as a parameter in Multi-scale MRF model,this algorithms perform better than any other techniques. It is observed from results that RSMAP algorithm provides improvised results as compared to MSAP for image segmentation.

3. Segmentation comparison

Author/Year	Segmentation techniques	category	Advantages	Disadvantages
Fernando C. Monteiro (2008)	spectral method and morphological algorithm of watershed			
R. V. Patil(2010)	K-means image			
Weihong Cui Yi Zhang (2010)	Band weight and NDVI (Normalized Difference Vegetation Index)	Edge Based Segmentation (Discontinuity present in the image is the significance of edge)	Images having contrast gives better result	Not good for multiple edge
Anna Fabijańska (2011)	Sobel Gradient filter with K-means			
Mohammed J. Islam(2011)	Sobel Edge Detector and Otsu Thresholding technique			
D. Barbosa (2012)	spectral method using Morphological Watershed algorithms			
Gang Chen (2009)	Least Square method	Region Based Segmentation (Divide image into multiple partitions)	Great for defining similarity of the region	Time and memory consuming
Zhen Hua, Yewei Li (2010)	ANN methods, Gabor filter and Guass-Laplace filters			
Tiancan Mei (2011)	Multi-scale MRF model(Markov random field)			

Based on segmentation survey region based segmentation have better for defining similarity of region. Depending upon the type of devise used for acquiring the finger vein image can choose Region of Interest based segmentation algorithm can be used.

4. Survey on finger vein extraction

N. Miura, A. Nagasaka, and T. Miyatake (2004) proposed repeated line tracking method for feature extraction. Extraction of the pattern is based on number of times the tracking lines pass through the points[15]. This method is based on line tracking, which starts at various positions by which Local dark lines are identified, and line tracking is executed by moving along the lines, pixel by pixel. When a dark line is not detectable, a new tracking operation starts at another position until all the dark lines in the image can be tracked. This is performed repeatedly by executing such local line tracking operations.

The loci of the lines overlap and the pattern of finger veins is obtained statistically. Although noise may also be tracked, it is emphasized to a smaller degree than the dark lines. This makes line extraction robust and also reduction of the number of tracking operations. The spatial reduction of the pattern can help to reduce computational cost.

M. Subramani (2011) proposed Radon Transform and Principle Component Analysis (PCA) method for extracting features from vein pattern consideringthe directional information of the vein image [16]. Features are derived by using Radon projections of vein image in different orientation for each projection. Using this algorithm, the project of image intensity vector at a specified angle of oriented radian line is computed. Based on this computation, the projection matrix is constructed from the individual projection. PCA analysis is applied to this projection matrix, singular values are calculated and arrangedin descending order to compose a feature vector. This feature vector is unique and also describe finger vein imagedistinctively.

D. Wang, J. Li, and G. Memik (2010) proposed Radon transform and Singular Value Decomposition (SVD) method for finger vein identificationb[17]. This algorithm attempts to exploit Radon transform to derive desirable directional features of finger vein image. Then SVD is applied to Radon space to obtain lower-dimensional feature vector to accelerate the identification speed.

V.Ramya and P.Vijaykumar (2014) performed feature extraction by using Haar classifier and line detection. Haar transform is a simplest of the wavelet transform [18]. This transform cross multiplies the function against the Haar wavelet with various shifts and stretches - like Fourier transform, cross multiplies a function against a sine wave with two phases and many stretches. The important feature of Haar transform is, it is fast for implementation and able to analyze the local feature.

Yang, G (2012) Local binary pattern (LBP) and local derivative pattern (LDP) are two similar format translators, and they were used as feature extraction method for finger vein. Based on LBP, A general framework personalized best bit map (PBBM) is proposed to use the best bits only for recognition [19]. These methods neglect the intrinsic distribution information of the vein vessel network and meanwhile increase the interference of the background.

M. Khalil-Hani and P.C. Eng., (2010) developed the feature extraction module utilizes the minutiae features extracted from the vein patterns for recognition. The minutiae points include bifurcation points and ending points [20]. The method used for minutiae feature extraction is cross number (CN) concept. It is the number of transaction from 0 to 1 and vice versa for the surrounding pixel, by this concept the pixels can be classified as ridge ending point or bifurcation point and in this way the vein pattern is extracted from the minutiae points.

M. Vlachos, E. Dermatas (2013) developed a two-step region growing method based on statistical attributes of derivative infrared images for pattern extraction. Initially, original image is filtered by four different Gaussian Kernels and subsequently partial derivatives of the obtained images are computed. Further, the Hessian matrix of these images is constructed and its eigenvalues are computed based on pixel by pixel basis [21]. The minimum eigenvalue and the absolute value of its gradient comprise the two characteristics (features) used in the two step region growing procedure. The region growing procedure is restricted by statistical attributes such as the mean value and the standard deviation of the segmented regions (vein and tissue). Due to the occurrence of some misclassifications, a final post processing based on morphological operations, is performed. This method achieves efficient segmentation of the image despite of intensity variations.

Inference from Literature Survey

Based on literature analysis, inference can be drawn as, for effective figure vein verification, various approaches had been proposed. These approached helps to extract the vein network from finger-vein images and showed promising performance on different databases. These approaches can be broadly grouped as – detecting Valley and line-like feature.

4.1. Detecting valley features

In this approach, clear regions of the finger-vein image and the pixel values in vein patterns are lower than those in background and thus the cross-sectional profile of a vein pattern shows a valley shape. Various approaches were proposed to detect the valley features. For example, the repeated line tracking methods extract the vein pattern by computing the difference between the center value and the neighboring ones in the Cross-sectional profile. In region growth-based approaches, a Gauss template is designed to compute the valley's depth and symmetry. In addition, as curvature is sensitive to the valley, curvature-based measures have been shown to be powerful for extracting finger-vein features.

5.2. Detecting line-like features

In this approach, a vein pattern is hypothetically defined to be a line-like texture in a predefined neighborhood region. This assumption has been supported by many works based on Gabor Filters, Matched Filters, Wide Line Detector (WLD) and neural networks. Gabor wavelets have been applied for ridge and edge detection to enhance the finger-vein image. The enhanced vein pattern is further segmented using a threshold to obtain a binary image for identification.

For the matched filters, different templates are considered to search vein segments along all possible directions. In WLD, the vein patterns are detected by comparing the value of the center pixel to the values of the other pixels within the mask. In, the fingervein image, by contrast, is enhanced based on curvelets, and then a local interconnection neural network with a linear receptive field is employed to learn straight-line vein features based on labeled patches. The network is trained to detect a horizontal line and the receptive field of the neural network is further rotated by an angle to extract other lines. Unfortunately, no details on the experimental setup are given and the pixels seem to be manually labeled.

The approaches above extract finger-vein patterns based on attribute assumptions such as valleys and straight-lines. As a result, they suffer from following problems:

These assumptions are not always effective to detect the finger vein patterns. Compared to background pixels, the vein pixel values from clear regions do correspond to valleys or straight-line attributes. so, in this case, the approaches above can distinguish vein from non-vein pixels. However, they cannot work well for ambiguous regions because noise can comprise some valley structures in the vein region while creating false valleys in the background.

How to learn a good representation of the vein patterns is still an issue for finger vein feature extraction. This has motivated many researchers to investigate a robust feature extraction approach for real-world finger-vein verification. Performance Evaluation of Various Finger-Vein Feature Extraction Techniques is listed below.

Author/year	Finger-vein Feature Extraction Techniques	No. of images	Performance Evaluation Metrics
N. Miura, A. Nagasaka, and T. Miyatake (2004)	Repeated Line Tracking	678	EER=0.145%, ROC=6.54%, Response Time=460ms, Mismatch Ratio=4.56%, Recognition Accuracy=77.94%
V.Ramya and P. Vijaykumar (2014)	Haar transform	20 employees images	precision of the template matching 87.5%
M. Subramani (2011)	Radon transform and Principal component analysis algorithm	100	FAR=0.008, FRR=0.0
D. Wang , J. Li, and G. Memik (2010)	Radon transform and Singular Value Decomposition (SVD)	1440	EER ranged from 3.15% up to 0.37%
M. Khalil-Hani and P.C. Eng., (2010)	Gradient-based thresholding using morphological operation and	7	Recognition Accuracy=93-95%, VAF(Variance Accounted For)=95%[training] and 93%[testing]

	Maximum Curvature Points in Image Profiles		
Yang, G (2012)	local binary pattern (LBP), and local derivative pattern (LDP) methods	2400	EER=0.13; EER For LDP=0.89, LBP=1.53, BINARISATION=2.32, Processing Time for LDP=112.5ms, LBP=44.7ms, BINARISATION=30.6ms
Ajay Kumar,(2012)	Even Gabor with Morphological methods	6264	ROC=0.43%, Recognition Accuracy=93.49%
M. Vlachos, E. Dermatas (2013)	A Region Growing Method Based on Statistical Attributes of Infrared Images [improved]	10	Mean Sensitivity=0.836, Mean Specificity=0.972, Mean Accuracy=0.942, Recognition Speed=100ms/person, FAR=5X, Recognition Accuracy=94.2%

Performance evaluation

To quantitatively evaluate the accuracy of finger-vein feature extraction techniques, various performance evaluation metrics are usually considered.

6.1. Database

For each technique, database must be prepared in advance for feature extraction. Size of database depends upon the number of participants and samples of each participant. A representative database should contain samples collected from males, females and different races [22], adults and children in diverse ages, etc. It is necessary to note that for each participant at least two sample vein images are required to be captured [23], one is used for enrolment and the other is used as query image for testing algorithm's performance.

6.2. Performance evaluation metrics

Following performance evaluation metrics are used for biometric systems:

1) False Accept Rate or False Match Rate (FAR or FMR)

The probability that the system incorrectly matches the input pattern to a non-matching template in the database. It measures the percent of invalid inputs which are incorrectly accepted. In case of similarity scale, if the person is imposter in real, but the matching score is higher than the threshold, and then he is treated as genuine that increases the FAR and hence performance also depends upon the selection of threshold value.

2) False Reject Rate or False Non-Match Rate (FRR or FNMR)

The probability that the system fails to detect a match between the input pattern and a matching template in the database. It measures the percent of valid inputs which are incorrectly rejected.

3) Receiver Operating Characteristic or Relative Operating Characteristic (ROC)

The ROC plot is a visual characterization of the trade-off between the FAR and the FRR. In general, the matching algorithm performs a decision based on a threshold which determines how close to a template the input needs to be for it to be considered a match. If the threshold is reduced, there will be fewer false non-matches but more false accepts. Correspondingly, a higher threshold will reduce the FAR but increase the FRR. A common variation is the Detection error trade-off (DET), which is obtained using normal deviate scales on both axes. This more linear graph illuminates the differences for higher performances (rarer errors).

4) Equal Error Rate or Crossover Error Rate (EER or CER)

The rates at which both accept and reject errors are equal. The value of the EER can be easily obtained from the ROC curve. The EER is a quick way to compare the accuracy of devices with different ROC curves. In general, the device with the lowest EER is most accurate.

5) Failure to Enroll Rate (FTE or FER)

The rate at which attempts to create a template from an input is unsuccessful. This is most commonly caused by low quality inputs.

6) Failure to Capture Rate (FTC)

Within automatic systems, the probability that the system fails to detect a biometric input when presented correctly.

7) Template Capacity

The maximum number of sets of data which can be stored in the system.

8) Response Time

In practical applications, Response Time must be taken into account. It is jointly determined by two factors viz, computational complexity of vein recognition algorithm and capability of processing platform including the adopted software, performance of CPU, memory size, etc

5. Conclusions

Based on this literature survey, presents an analysis of different techniques used in the process of finger-vein segmentation, feature extraction for biometric authentication and identification. This study paper presents the fundamental principles, various segmentation procedures and feature extraction techniques and performance evaluation metrics adopted in the course of finger vein identification. Exploring the proposed works in the field of vein based identification principle, literatures and commercial utilization experiences, different Finger-vein Feature Extraction Techniques offer different levels of performance, spoofing resistance, robustness, security and accuracy. A careful analysis of requirement and system performance will be helpful for developing new efficient algorithm with better performance in the research work.

References

[1] P. Gupta, "An accurate finger vein based verification system," Digital Signal Processing, vol. 38, pp. 43-52, 3// 2015.

[2] Y. Jinfeng and L. Xu, "Efficient Finger Vein Localization and Recognition," in Pattern Recognition (ICPR), 2010 20th International Conference on, 2010, pp. 1148-1151.

[3] David Mulyono, "A study of finger vein biometric for personal identification" IEEE Proceedings of the Tnternational Symposium Biometrics and Security technologies, pages 134-141, 2008.

[4] Zhi Liu and Shangling Song, "An embedded real-time finger-vein recognition system for mobile devices" IEEE Transactions on Consumer Electronics, 58(2), 2012. https://doi.org/10.1109/TCE.2012.6227456.

[5] F. C. Monteiro and A. Campilho, "Watershed framework to region-based image segmentation," in Proc. International Conference on Pattern Recognition, ICPR 19th, pp. 1-4, 2008. https://doi.org/10.1109/ICPR.2008.4761587.

[6] M. Hameed, M. Sharif, M. Raza, S. W. Haider, and M. Iqbal, "Framework for the comparison of classifiers for medical image segmentation with transform and moment based features," Research Journal of Recent Sciences, vol. 2277, p. 2502, 2012.

[7] R. Patil and K. Jondhale, "Edge based technique to estimate number of clusters in k-means color image segmentation," in Proc. 3rd IEEE International Conference on Computer Science and Information Technology (ICCSIT), pp. 117-121, 2010. https://doi.org/10.1109/ICCSIT.2010.5563647.

[8] W. Cui and Y. Zhang, "Graph based multispectral high resolution image segmentation," in Proc. International Conference on Multimedia Technology (ICMT), pp. 1-5, 2010.

[9] A. Fabijanska, "Variance filter for edge detection and edge-based image segmentation," in Proc. International Conference on Perspective Technologies and Methods in MEMS Design (MEMSTECH), pp. 151-154, 2011.

[10] M. J. Islam, S. Basalamah, M. Ahmadi, and M. A. S. hmed, "Capsule image segmentation in pharmaceutical applications using edge-based techniques," IEEE International Conference on Electro/Information Technology (EIT), pp. 1-5, 2011.

[11] D. Barbosa, T. Dietenbeck, J. Schaerer, J. D'hooge, D. Friboulet, and O. Bernard, "B-spline explicit active surfaces: An efficient framework for real-time 3-D region-based segmentation," IEEE Transactions on Image Processing, vol. 21, pp. 241-251, 2012. https://doi.org/10.1109/TIP.2011.2161484.

[12] G. Chen, T. Hu, X. Guo, and X. Meng, "A fast region-based image segmentation based on least square method," in Proc. IEEE International Conference on Systems, Man and Cybernetics, SMC, pp. 972-977, 2009. https://doi.org/10.1109/ICSMC.2009.5346073.

[13] Z. Hua, Y. Li, and J. Li, "Image segmentation algorithm based on improved visual attention model and region growing," in Proc. 6th International Conference on Wireless Communications Networking and Mobile Computing (WiCOM), pp. 1-4, 2010. https://doi.org/10.1109/WICOM.2010.5601008.

[14] T. Mei, C. Zheng, and S. Zhong, "Hierarchical region based Markov random field for image segmentation," in Proc. International Conference on Remote Sensing, Environment and Transportation Engineering (RSETE), pp. 381-384, 2011.

[15] N. Miura, A. Nagasaka, and T. Miyatake, "Feature extraction of finger vein patterns based on repeated line tracking and its application to personal identification", Machine Vision Application, vol. 15, no.4, pp.194–203, 2004. https://doi.org/10.1007/s00138-004-0149-2.

[16] M.Subramani, "Highly secure and reliable user identification based on finger vein patterns" Double Blind Peer Reviewed International Research Journal, 11, 2011.

[17] D. Wang , J. Li, and G. Memik, "User identification based on finger vein patterns for consumer electronics devices", IEEE Transactions on Consumer Electronics, vol. 56, no. 2, pp. 799-804, 2010. https://doi.org/10.1109/TCE.2010.5506004.

[18] V.Ramya and P.Vijaykumar, "A novel design of finger vein recognition for personal authentication and vehicle security" Journal of Theoretical and Applied Information Technology, 65, 2014.

[19] Yang, G., Xi, X., Yin, Y.: Finger Vein Recognition Based on a Personalized Best Bit Map.Sensors 12, 1738–1757 (2012) https://doi.org/10.3390/s120201738.

[20] M. Khalil-Hani and P.C. Eng., "FPGA-based embedded system implemention of finger vein biometrics" IEEE Symposium on Industrial Electronics and Applications, 2010.

[21] M. Vlachos, E. Dermatas: "A Region Growing Method Based on Statistical Attributes of Infrared Images for Finger Vein Pattern Extraction",Biomedical Engineering Research,March. 2013, Vol. 2 Iss. 1, PP. 1-15.

[22] Wang Y, T. Liu and J. Jiang 2008b, "A Multi resolution waveletalgorithm for hand vein pattern recognition", Chinese Optics Lett., 6:657-660. https://doi.org/10.3788/COL20080609.0657.

[23] Kono, M, H.Ueki and S.Umemura (2002), "Near Infra-red FingerveinPattern for Personal Identification", Applied Optics, 41:7429-7436. https://doi.org/10.1364/AO.41.007429.

[24] C.Nalini, Shwtambari Kharabe," A Comparative study on different techniques used for finger –vein authentication",International Journal of Pure and Applied Mathematics,Vol-16,No.8,2017,pp 327-333.