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Research paper

A Comprehensive Review on Various State-of-the-Art Techniques for Image Enhancement

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Abstract

Image processing involves many pre-processing techniques. One such technique is image enhancement. This is the most difficult phase in processing because it should enhance an image to such a clear visual level that human eyes should discern it. It is proven that the enhanced images are able to provide the high rate accuracy, increased efficiency, robust results in case of criminal investigations, security applications etc. Here, the goal is to enhance a degraded image, noisy, foggy or low-resolution image to obtain the output image which appears better than the original. This survey paper provides a brief analysis of techniques and algorithms of image enhancement**.**

Keywords: *Face recognition, image enhancement techniques, contrast and visibility, uneven illumination, Human Visual System*

1. Introduction

Image processing means transforming an image into digital version to get its improved quality with a view to extracting detailed information regarding the image in question. It includes 1) examining non-visible objects 2) applying filters to get a good quality image 3) identifying the objects. We all can agree that having a clear and high-quality photograph is the need of the hour [25]. Fields such as defence, military, medicine depend highly on the image processing technologies. Be it satellite image or an aerial image or even real time photograph, the major challenge faced is removing the noise and quality improvement of image so that a meaningful deduction can be made out of it [24].

Face is the only means of identifying a human being. One may come across problems with uneven quality of face images because it may lead to lesser identification rate [17]. A method of perfecting an image captured in inconsistent gleam is called image enhancement. It comprises of sharpening the edges, modifying the contrast of the image to make resultant image's features more graspable. The principle behind image enhancement is to refine an image where image obtained after enhancement is more suited than the input image for any objective [35]. Image enhancement has a considerable role in perfecting the sketches which involve noise or blurring [47].

Image enhancement doesn't modify the internal structure of the image. Instead, it tries to represent image in a suitable manner. One can determine the enhancement rate by choosing the different metrics such as False Rejection Rate(FRR), PSNR (Peak Signal to Noise Ratio), AMBE (Absolute Mean Brightness Error) and many more [2]. Image can be enhanced either pixel by pixel or directly on image itself. Algorithms are continuously being developed or modified to get a better resolution of the images. Image quality, speed at which algorithm processes and complexity are the terms which decide to switch over different enhancing algorithms. As we know, degradation of an image causes difficulty in recognition. One must choose fruitful algorithms according to the cost and the output [29]. Having this in mind, this particular review paper briefs various enhancement techniques, algorithms applied on different applications to picturize how well they work in real-time.

2. An Exhaustive Review on Various Enhancement Techniques

Deeksha Kapil & Abhilasha [1] illustrated that texture features are affected as the resolution changes especially for the low-resolution images. So, they offered EULBP where they matched the individual identity with the many database images. For the face recognition purpose, they have used the low-resolution images which are then enhanced using Local Ternary Pattern with the combination of DWT (Discrete Wavelet Transform) and the DCT (Discrete Cosine Transform). LTP is used to compute texture features of enhanced images. Distance classification is done using Chi-Square classifier. The database being used is ORL database. They concluded that DWT&DCT embedded with LTP result in increased accuracy in the area of face recognition.

Neha Sharma et al. [2] reviewed different enhancing algorithms for bringing out the best algorithm for enhancement. Because, processing speed, computational complexity, image quality are the terms which make the algorithms efficient. With that particular aim, authors have introduced 6 various enhancement algorithms namely Histogram Equalization(HE), Adaptive HE, CLAHE, Modified CLAHE, BBHE. Performance metrics is also calculated using CHUK dataset subjectively and objectively. Hence, they revealed that Modified CLAHE increases the contrast of image more efficiently with respect to PSNR and AMBE when compared to other five techniques.

M Hakeem Selamat & Helmi MD Rais [3] presented a model called hybrid SVM to enhance the feature extraction phase. In this particular phase, DWT, PCA techniques have been used for

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compressing images, dimension reduction and feature extraction. They tested against Cambridge ORL face database. In this paper, calculation of accuracy relies on 2 SVM kernel. HM-SVM is a combination of two or binary classifiers. Authors have compared this model with the classic HM-SVM. It is found that, with the help of polynomial kernel the enhancement quality becomes better in classic HS-SVM by 3.13%-6.56% and in radial basis function kernel by 1.88-5.31%.

Nithyananda C R et al. [4] surveyed different enhancement techniques based on Histogram Equalization. They explained how well the two types of images can be enhanced using the Histogram Equalization. Out of the two types of images, first one is the grey level and second one is the RGB. They found that enhancement is not possible for grey level images because of the hue-preservation. The experimental results showed that RMSHE technique is more appropriate in terms of computational capabilities compared to the other techniques. They also quoted that to obtain the best image quality, one must choose sub-images without vagueness.

Garima Yadav et al. [5] presented CLAHE (Contrast Limited Adaptive Histogram Equalization) enhancement algorithm to increase the clarity of the foggy images or videos and to remove the excess noise. In order to overcome the limitations of HE & AHE algorithms, CLAHE is introduced which can be implemented on both heterogeneous and homogeneous foggy images or videos. The proposed method includes various steps. They are, 1) collection of foggy images 2) getting the number of regions in rows and columns for enhancement, 3) dividing the region into sub region and mapping the tiles 4) producing the grey level image 5) interpolating the obtained image to get the enhanced image. Clip limit and elapse time are the two important parameters taken into consideration. The experimental results showed that the visible edges of foggy image are increased by 1.024% and saturation factor is nullified.

Vidya V et al. [6] introduced a novel approach of normalizing illumination to solve the problem of different unfavourable lighting conditions using SIET (Selective Illumination Enhancement Technique) where Energy function is used to decide the correction factor. Here uniformity illumination of the image is achieved by separating the dark regions. SIET targets to put to zero the illumination variations. In the FR system, each stage examined is improved. For enhancing purpose Threshold based DWT is used. They observed that the process of retaining the edges in DWT increases the rate of face recognition when related to the other enhancing techniques such as Laplacian of Gaussian. Experimental study is conducted on colour FERET, Extended Yale B, ORL and UMIST database.

Niloofar Amani et al. [7] proposed the method which relies upon the contrast enhancement which uses high-frequency that emphasizes filtering and histogram equalization. In this method, digital filtering is used to enhance image contrast and global visualization. To implement this, first step involves converting the face images to high frequency domain and then using Otsu method, global thresholding technique has been employed for the image. 2D PCA (2Dimensional Principle Component Analysis) and 2D LDA (2D Linear Discriminant Analysis) are employed for extracting the feature and dimensionality reduction. In the last stage of the method, classification is done by measuring the simple minimum distance. Experimental study is done using AT & T and Yale databases. Improved recognition rate of 95.756 is obtained using the proposed method.

Chiou Shi Lim & Haidi Ibrahim [8] proposed two different approaches for enhancing the facial images. One is the mixture of histogram equalization with gamma intensity correction(CHEGIC) and second one is block based contrast enhancement technique. They calculated the performance of above mentioned methods against the 3 different enhancing algorithms. Henceforth the result obtained after the comparison shows that CHEGIC has the highest probability of detecting the faces and also good at performance because it enhances the image by unaffecting the features.

Haidi Ibrahim & Nicholas Sia Pik Kong [9] introduced a new method which eliminates the visual deterioration so as to produce the mean intensity which is similar to the input mean intensity. It undergoes several actions such as the one that uses Gaussian filter to ease the input histogram. Secondly, using the eased histogram, it identifies the location of local maximum. Thirdly, portion is generalized into a new dynamic range and every partition is equalized independently. In the last step, brightness normalization is calculated to balance the input mean intensity. The novelty of this approach is that the proposed technique successfully enhances the images without producing the noise, saturation effect and most importantly image's mean brightness is assured.

Weiguo Wan & Hyo Jong Lee [10] have put forward the detail enhancement strategy which is based on nonsubsampled Shearlet Transform(NSST) with an objective to overcome the problems of noising and blurring. Here, the primary-sketch is synthesized using the exemplar-based technique. Then, the details of the test image are extracted and combined with the primary-sketch through NSST decomposition and reconstitution to get the final image. Neighbouring candidate patches are calculated by Euclidean distance classifier. The experiment is conducted on CUHK, AR and XM2VTS databases. Thus, the obtained results surpassed the enhancement qualitatively and quantitatively.

Amina Saleem et al. [11] proposed fusion-based contrast enhancement technique to overcome the difficulties of local and global enhancement techniques. This method includes selection of more detailed features of the input image and multi-resolution (MR) blending is used to fuse two or more images. The proposed work is mainly applied in the non-real-time application. Henceforth the experiment showed that the enhancement efficiency is increased wherein the saturation level and brightness of an image are unaffected.

Ming-Suen & Jin-Jang Leou [12] explained weaknesses of most of the colour image enhancing methods. To solve them, they presented Genetic Algorithm(GA) technique. Generalized transforms are taken into consideration for enhancing the degraded colour images using some nonlinear transforms. They focussed mainly on the luminance, hue, saturation (LHS) to fit the human visual system characteristics. They remarked that fitness function in this particular approach is larger when compared to other colour enhancement techniques. They tested against 4 test images each of size 256*256.

Sharumathi K & R.Priyadharshini [13] explained about the speckle noise which is usually present in the acoustic images which tend to be grey level. Therefore, they reviewed various techniques for enhancing under water images which include 1) wavelet 2) curvelet and 3) contourlet. In the curvelet method, the given image is divided into sub bands whereas in wavelet, the reverberation is removed by shrinkage approach. In order to get the better quality acoustic images, inverse of wavelet function is calculated. Contourlet technique makes use of a nonlinear function which converts to an enhanced image by extracting illumination. Filtering techniques have been imposed to enhance the quality of the image. Hence, the study suggested that contourlet is the best approach in all kinds of features of an image compared to other two techniques.

Andrea Polesel et al. [14] explained the method to sharpen the low-resolution images via adaptive filter. This is implemented in such a way that filtering is applied only to the highly detailed areas whereas it is not applied in the areas where there are no clear details. Abrupt edges are not selected in this filtering because the aim is to enhance only the medium details rather than the high-level details. Since the mentioned filtering doesn't enhance the smooth areas, researchers found it to be the most robust approach and less noisy output is obtained.

Lizuo Jin et al. [15] introduced an Adaptive Enhancement(AE) algorithm. Here Entropy Error Rate(ERR) is used as the measure of quality for the enhanced image to that of original. After modifying the intensity levels of the images, it is integrated with the histogram ridges to enhance the image more optimally to get the lowered EER. It makes use of HE for the intensity distribution.

The study is done using Yale B databases and some of their own collections of images taken in good condition. The researchers quoted that the accuracy of detecting the face is increased remarkably after the enhancement and the above-mentioned algorithm outperforms as compared to other algorithms.

N. Sangeetha & K.Anusudha [16] focussed on applying enhancement approaches to the images which suffer from haze and foggy atmosphere. Law transformation is one of the techniques which surpasses the brightness level of the image. High-boost filtering method, on the one hand, enhances the high frequency component and, on the other hand, retains low frequency component. Then it points out the significance of edges and results in the process of sharpening image. Homographic filtering method is employed to modify the image's illumination which is non-uniform in nature. DWT is similar to above mentioned technique where it improves overall frequency of image. Experiment is done on two foggy images where DWT has outperformed above methods with regard to PSNR.

Qianwen Wan & Karen Panetta [17] presented automatic face recognition to address the problem of comparing computerized composite sketches to the corresponding image by making use of HVS algorithms. This framework helps in finding and ranking nearest matched test image to the stored database images. Database of forensic sketches with their corresponding images is archived. Finally, accuracy of matching computerized sketches and accuracy of matching forensic photos are compared. Hence, the experimental results provided high efficiency and accuracy.

Qianwen Wan & Karen Panetta [18] proposed FR (Face Recognition) system employing the HVS algorithms fused with region weighted model and logarithm LTP (Local Binary Pattern) descriptors. This approach surpasses the performance of LTP. Closest matched test images to stored database images are rapidly found and ranked. In addition to this, weighted region histogram was used to enhance unique facial features. Comparison is carried out between weighted and non-weighted HVS LBP where weighted HVS LBP is proved to be better. AT&T, Yale face, FERET test databases were used.

Nicholas Davis et al. [19] introduced FR system of low-cost to capture images by utilizing a COTS (commercial off-the-shell) UAV (unmanned aerial vehicle). Because of the accurate recognition and detection features, system can be used in security application. This approach is focussed on providing image enhancement and recognition with the combination of HVS based detection and low-cost COTS UAVs. Here, in this recognition algorithm, recognition quality is assured with less number of training set. AT&T database and images captured by AR. Drone 1.0. Experimental study showed high modularity, accurate and flexible.

Qianwen Wan et al. [20] presented novel approach of FR system utilizing HVS based technique called logarithmical image visualization method to overcome the problem of non-uniform illumination. Proposed method makes use of the logarithmical image visualization fused with the LBP (Local Binary Pattern) to accomplish particular feature extraction for FR system. Yale database, Extended Yale and ATT are used as test databases to emphasize the effectiveness of enhancing technique. Authors remarked that the resultant images were high contrast, high detailed suitable for face detection. Hence, the proposed method assures efficiency, robustness.

3. Observation of Results Achieved Using Aforesaid Enhancement Techniques

Fig. 1: Input image (left) and enhanced image using SIET (right)

Fig. 2: Input image (left) and enhanced image using AE (right)

Fig. 3: Input image (left) and enhanced image using BBHE (right)

Fig. 4: Input image (left) and enhanced image using RMSHE (right)

Table I: Recognition Rate of Various Techniques on Different Datasets

Article	Pixel	Dataset	Recognition Rate (%)
[1]	92*112	ORL	93.12%
	64*64		92.50%
	32*32		90.62%
[6]	384*256	Color FERET	85.41%
	480*640	Extended Yale B	97%
[7]	95*105	Yale and AT&T	95.75%
[15]	256*256	Yale B	89.01%
[20]	38*124	AT&T	88%
		Yale B	88.5%
		FERET	85%

Table II overview on the application of various enhancement techniques in the field of image processing

Article	Enhancement techniques	Application	Limitations
[1], [18]	HVS based on LTP	Face Recognition	Only individual identity is matched.
[2], [4], [5], [7] [8]	HE, BBHE, MHE, AHE, CLAHE, M-CLAHE, CHEGIC	Facial recognition under noisy, blurred, foggy, uniform illumination conditions	Less sharpness, doesn't maintain brightness, no natural appearance, performance relies on number of sub-images.
[6], [20]	SIET	Face recognition under non-uniform illumination	Noise and blurring effects of images cannot be removed.
[10],	NSST, HVS	Face-sketch	Cannot increase the

[17]		synthesis	brightness or contrast. Not possible to detect single face from group photos and vice versa.
[19]	HVS+COTS UAV	Unmanned aerial vehicle	Object detection and automatic cropping of facial images are not covered

4. Conclusion

The review paper summarizes rate of identification of face using different enhancement technique to emphasize the quality of an images which are noisy, blurred or captured in unconstrained illumination, etc. There is a huge necessity of enhancing the images for better visual appearance for detection. Otherwise it would be of no use to deal with image. In few of the surveyed papers DWT, DCT and threshold-based DWT are the common approaches to enhance the images. Some of the commonly used algorithms such as HE, Adaptive HE, BPDHE have been used to make contrast of the facial images better. Techniques like CLAHE for defogging the haze or fog images are also been discussed. Particularly for colour images, technique based on Genetic Algorithm is implemented which mainly concentrates on LHS metrics. Overall, most of the techniques in this review paper have demonstrated to be practical, effective, robust and gives high level of accuracy. Number of enhancement techniques available for sketches are very few in comparison with the techniques available for images. The scope of enhancement in case of composite sketches and forensic sketches is left out. Therefore, it would have been better if an in-depth research work is undertaken.

References

[1] Kapil, D. & Abhilasha (2015, September). Face recognition of blurred images using image enhancement and texture features. In *Next Generation Computing Technologies (NGCT), 2015 1st International Conference on* (pp. 894-897). IEEE.

[2] Sharma, N., Saurav, S., Singh, S., Saini, R., & Saini, A. K. (2015, August). A comparative analysis of various image enhancement techniques for facial images. In *Advances in Computing, Communications and Informatics (ICACCI), 2015 International Conference on* (pp. 2279-2284). IEEE.

[3] Selamat, M. H., & Rais, H. M. (2016, August). Enhancement on image face recognition using Hybrid Multiclass SVM (HM-SVM). In *Computer and Information Sciences (ICCOINS), 2016 3rd International Conference on* (pp. 424-429). IEEE.

[4] Nithyananda, C. R., & Ramachandra, A. C. (2016, March). Review on histogram equalization based image enhancement techniques. In *Electrical, Electronics, and Optimization Techniques (ICEEOT), International Conference on* (pp. 2512-2517). IEEE.

[5] Yadav, G., Maheshwari, S., & Agarwal, A. (2014, September). Contrast limited adaptive histogram equalization based enhancement for real time video system. In *Advances in Computing, Communications and Informatics (ICACCI, 2014 International Conference on* (pp. 2392-2397). IEEE.

[6] Vidya, V., Farheen, N., Manikantan, K., & Ramachandran, S. (2012). Face recognition using threshold based DWT feature extraction and selective illumination enhancement technique. *Procedia Technology*, 6, 334-343.

[7] Amani, N., Shahbahrami, A., & Nahvi, M. (2013). A new approach for face image enhancement and recognition. *International Journal of Advanced Science and Technology*, 52(01), 1-10.

[8] Lim, C. S., & Ibrahim, H. (2013). Image enhancement for face images using spatial domain processing. *International Journal of Advanced Research in Computer Science and Electronics Engineering (IJARCSEE)*, 2(11), pp-714.

[9] Ibrahim, H., & Kong, N. S. P. (2007). Brightness preserving dynamic histogram equalization for image contrast enhancement. *IEEE Transactions on Consumer Electronics*, 53(4).

[10] Wan, W., & Lee, H. J. (2017, October). A detail enhancement strategy for face sketch synthesis based on NSST. In *Information and Communication Technology Convergence (ICTC), 2017 International Conference on* (pp. 784-788). IEEE.

[11] Saleem, A., Beghdadi, A., & Boashash, B. (2012). Image fusion-based contrast enhancement. *EURASIP Journal on Image and Video Processing*, 2012(1), 10.

[12] Shyu, M. S., & Leou, J. J. (1998). A genetic algorithm approach to color image enhancement. *Pattern Recognition, 31*(7), 871-880

[13] Sharumathi, K., & Priyadharsini, R. (2016, March). A survey on various image enhancement techniques for underwater acoustic images. In *Electrical, Electronics, and Optimization Techniques (ICEEOT), International Conference on* (pp. 2930-2933). IEEE.

[14] Polesel, A., Ramponi, G., & Mathews, V. J. (2000). Image enhancement via adaptive unsharp masking. *IEEE transactions on image processing*, 9(3), 505-510.

[15] Jin, L., Satoh, S. I., & Sakauchi, M. (2004, August). A novel adaptive image enhancement algorithm for face detection. In *Pattern Recognition, 2004. ICPR 2004. Proceedings of the 17th International Conference on* (Vol. 4, pp. 843-848). IEEE.

[16] Sangeetha, N., & Anusudha, K. (2017, January). Image defogging using enhancement techniques. In *Computer, Communication and Signal Processing (ICCCSP), 2017 International Conference on* (pp. 1-5). IEEE.

[17] Wan, Q., & Panetta, K. (2016, May). A facial recognition system for matching computerized composite sketches to facial photos using human visual system algorithms. In *2016 IEEE Symposium on*(pp. 1-6).

[18] Wan, Q., Panetta, K., & Agaian, S. (2015, September). Autonomous facial recognition based on the human visual system. In *Imaging Systems and Techniques (IST), 2015 IEEE International Conference* on (pp. 1-6). IEEE.

[19] Davis, N., Pittaluga, F., & Panetta, K. (2013, April). Facial recognition using human visual system algorithms for robotic and UAV platforms. In *Technologies for Practical Robot Applications (TePRA), 2013 IEEE.*

[20] Wan, Q., Panetta, K., & Agaian, S. (2017, May). Autonomous facial recognition system inspired by human visual system based logarithmical image visualization technique. In *Mobile Multimedia/Image Processing, Security, and Applications 2017* (Vol. 10221, p. 1022106). International Society for Optics and Photonics.

[21] Sapna Josephus, C., & Remya, S. (2012). Enhancement Techniques for Local Content Preservation and Contrast Improvement in Images. *arXiv preprint arXiv:1203.1823*.

[22] Huang, K. Q., Wang, Q., & Wu, Z. Y. (2006). Natural color image enhancement and evaluation algorithm based on human visual system. *Computer Vision and Image Understanding*, *103*(1), 52-63.

[23] Al-amri, S. S., Kalyankar, N. V., & Khamitkar, S. D. (2010). Linear and non-linear contrast enhancement image. *International Journal of Computer Science and Network Security*, *10*(2), 139-143.

[24] Bedi, S. S., & Khandelwal, R. (2013). Various image enhancement techniques-a critical review. *International Journal of Advanced Research in Computer and Communication Engineering, 2(3).*

[25] Nancy, E., & Kaur, E. S. (2013). Comparative Analysis and Implementation of Image Enhancement Techniques Using MATLAB. *International Journal of Computer Science and Mobile Computing, 2(4).*

[26] Mishra, P., Sinha, M. K., Shivakumar, H., Krishnamurthy, K. N., Akashdeep, B. N., Khan, S. N., ... & Shewale, M. S. R. (2014). Different Approaches of Image Enhancement. *International Journal of Research in Advent Technology*, *2*(8), 106-109.

[27] Panetta, K., Zhou, Y., Agaian, S., & Jia, H. (2011). Nonlinear unsharp masking for mammogram enhancement. *IEEE Transactions on Information Technology in Biomedicine*, *15*(6), 918-928

[28] Panetta, K., Agaian, S., Zhou, Y., & Wharton, E. J. (2011). Parameterized logarithmic framework for image enhancement. *IEEE Transactions on Systems, Man, and Cybernetics, Part B (Cybernetics), 41(2),* 460-473

[29] Dhariwal, S. (2011). Comparative analysis of various image enhancement techniques. *International Journal of Electronics & Communication Technology (IJECT), 2*(3), 91-95.

[30] Bhateja, V., Misra, M., & Urooj, S. (2016). Human visual system based unsharp masking for enhancement of mammographic images. *Journal of Computational Science.*

[31] Walha, R., Drira, F., Lebourgeois, F., Alimi, A. M., & Garcia, C. (2016). Resolution enhancement of textual images: a survey of single image-based methods. *IET Image Processing, 10(4)*, 325-337
[32] Lee, J. S. (1980). Digital image enhancement and noise filtering by use of local statistics. *IEEE transactions on pattern analysis and machine intelligence*, (2), 165-168.
[33] Suganya, P., Gayathri, S., & Mohanapriya, N. (2013). Survey on Image Enhancement Techniques. *International Journal of Computer Applications Technology and Research*, 2(5), 623-meta.
[34] Tang, B., Sapiro, G., & Caselles, V. (2001). Color image enhancement via chromaticity diffusion. *IEEE Transactions on Image Processing, 10(5)*, 701-707.
[35] Maini, R., & Aggarwal, H. (2010). A comprehensive review of image enhancement techniques. *arXiv preprint arXiv:1003.4053*.
[36] Pizer, S. M., Amburn, E. P., Austin, J. D., Cromartie, R., Geselowitz, A., Greer, T., ... & Zuiderveld, K. (1987). Adaptive histogram equalization and its variations. *Computer vision, graphics, and image processing, 39*(3), 355-368.
[37] Rana, M. E., Zadeh, A. A., & Alqurneh, A. M. M. (2017). Use of image enhancement techniques for improving real time face RECOGNITION EFFICIENCY ON WEARABLE GADGETS. Journal of Engineering Science and Technology, 12(1), 155-167.
[38] Kim, T. K., Paik, J. K., & Kang, B. S. (1998). Contrast enhancement system using spatially adaptive histogram equalization with temporal filtering. *IEEE Transactions on Consumer Electronics, 44(1)*, 82-87.
[39] Lu, L., Zhou, Y., Panetta, K., & Agaian, S. (2010, April). Comparative study of histogram equalization algorithms for image enhancement. In *SPIE Defense, Security, and Sensing* (pp. 770811-770811). International Society for Optics and Photonics.
[40] Tan, X., & Triggs, B. (2010). Enhanced local texture feature sets for face recognition under difficult lighting conditions. *IEEE transactions on image processing*, 19(6), 1635-1650.
[41] Rao, D. H., & Panduranga, P. P. (2006, December). A survey on image enhancement techniques: classical spatial filter, neural network, cellular neural network, and fuzzy filter. *In Industrial Technology, 2006. ICIT 2006. IEEE International Conference on* (pp. 2821-2826). IEEE.
[42] Rana, M. E., Zadeh, A. A., & Alqurneh, A. M. M. (2017). Use of image enhancement techniques for improving real time face recognition efficiency on wearable gadgets.*Journal of Engineering Science and Technology, 12*(1), 155-167.
[43] Perumal, K., & Perumal, N. S. (2013). Image enhancement for face recognition using color segmentation and Edge detection algorithm. *International Journal of Computer Science & Communication Networks, 3*(3), 187.
[44] D'Cunha, N. W., Birajdhar, S. A., Manikantan, K., & Ramachandran, S. (2013, October). Face recognition using Homomorphic Filtering as a pre-processing technique. In *Emerging Trends in Communication, Control, Signal Processing & Computing Applications (C2SPCA), 2013 International Conference on* (pp. 1-6). IEEE.
[45] Wharton, E., Panetta, K., & Againan, S. (2007, April). Human visual system based multi-histogram equalization for non-uniform illumination and shoadow correction. In *Acoustics, Speech and Signal Processing, 2007. ICASSP 2007. IEEE International Conference on* (Vol. 1, pp. I-729). IEEE.
[46] Aarthi, R., Anjana, K. P., & Amudha, J. (2016). Sketch based image retrieval using information content of orientation. *Indian Journal of Science and Technology, 9*(1).
[47] Zhou, Y., Panetta, K., & Agaian, S. (2010, July). Human visual system based mammogram enhancement and analysis. In *Image Processing Theory Tools and Applications (IPTA), 2010 2nd International Conference on* (pp. 229-234). IEEE.
[48] Kokila, R., Sannidhan, M. S., & Bhandary, A. (2017, March). A study and analysis of various techniques to match sketches to Mugshot photos. In *Inventive Communication and Computational Technologies (ICICCT), 2017 International Conference on* (pp. 41-44). IEEE.
[49] Sannidhan, M. S., & Ananth Prabhu, G. A Comprehensive Review on Various State-Of-The-Art Techniques for Composite Sketch Matching.
[50] Kokila, R., Sannidhan, M. S., & Bhandary, A. (2017). A novel approach for matching composite sketches to mugshot photos using the fusion of SIFT and SURF feature descriptor.*2017 International Conference on Advances in Computing, Communications and Informatics (ICACCI)*. doi:10.1109/icacci.2017.8126046