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Face Recognition System using Color based Texture Pattern

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ABSTRACT

Face recognition is a technique used for video surveillance, crime prevention, person verification, etc. It is usually used by security systems in metropolitan life. Researches on face recognition, as a part of facial image processing are increasing recently. This system uses face as the biometric information of the humans which can be applied easily instead of other biometrics like fingerprint, iris, signature etc., since any other type of biometrics are not much reliable for non-cooperative people. This paper proposes a face recognition system using chromatic-texture feature. The Three Chromatic Texture Pattern (TCTP) used in this work can able to get the texture and color information of the image. The performance analysis of this work gives better results when compared with the previous works.

Key words: About four key words or phrases in alphabetical order, separated by commas.

1. INTRODUCTION

The effects of various imaging conditions like occlusion and illumination make face recognition more complex. In image analysis, face recognition system may have face detection and face recognition a parts. Face detection identifies position of the face in images, whereas face recognition classifies the images by using its structured properties. This classification is done by utilizing the facial feature components like eye alignment, color, texture etc. The images used for recognition are called standard image. Recognition algorithm uses images to do the recognition and algorithm for detection detects the faces. Also the detection algorithms images or objects present in the face like nose, eyes, eyebrows and mouth. For recognizing face, acquiring image is the first step. Detection of face is the second step. Recognition of face is the third step and finding the person identity is the last step. Figure 1gives the steps for face recognition system.

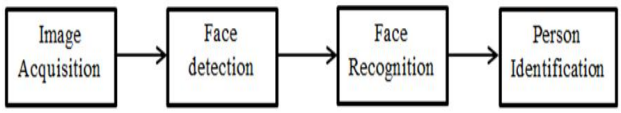

Figure 1: Steps of face recognition system

1. RELATED WORK

Acquisition of images from camera to computational medium is done. Frame grabber is used for this. The input face image is given to model for face detection to extract the faces. Detection of faces can be done by many algorithms [1 - 29], it may be based on knowledge- [1 - 15] or appearance [16 - 29]. Knowledge-based techniques are based on the features that make a face. Learning methods are used for appearance-based methods. The face recognition methods should be applied after the face detection methods. The standard images are used for implementing face recognition. After the creation of standard images, recognition algorithms are used to classify the images [30 - 43].
The detection algorithms can be classified based on image and knowledge. The various methods used for face detection are shown in Figure 2.

Knowledge-Based works use the details of face features such as eyes, mouth, nose, etc., Skin color is modeled by color spaces or Template Matching. The image-based methods use algorithms which can learn the images and take a decision based on it. The proposed work is a knowledge-based work.

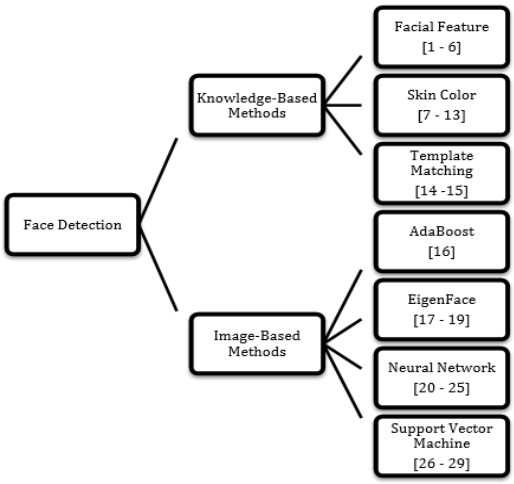

Figure 2: Classification of detection algorithms

2. PROPOSED WORK

An image cannot be represented with best single perceptual subjectivity because of the variation of conditions in the place where the image is taken. So, a good representation of image is still an open challenge. Human color vision representation is tried by many researchers. Forming a relevant notation of images is a challenge. The human color vision [44] imparting can help us to do this. A detailed study on this is done. Human color vision can be incorporated into the images by working on separated color spaces [45]. Also, this proposed work works on texture information through separated color space [46]. Here we use the method called Three Chromatic Texture Pattern (TCTP) [47].

Proposed work's contributions include

1. The textural-color feature is used here apart from relying on gray level information.
2. The extraction of features in three different patterns gives more reliable feature.

Six different sequences of patterns are created. The combined sequences are called as TCTP since it is formed three distinct color space interaction codes from an image. Different sequences with different inter-channel interaction using color combinations in distinct positions are formed. Equation (1) gives the pattern formed. The pattern of the image is formed with G-B-R, B-R-G, and R-G-B color spaces which are interactive are formed by replacing $C_1C_2C_3$ in Equation (1).

$$[Pattern_{c_1c_2c_3}]_{jk} = h(j,k)]_{j=1,2,\ldots,m,\ k=1,2,\ldots,n} \quad (1)$$

This kind of identification of pattern defines the dependency one pixel with another pixel which will provide the texture information. Instead of using the same plane, we take the information of pixels from different planes which help us to get the color information. Thus, this model uses six different combinations of pattern sequences which differs for odd and even rows. $h(j,k)$ can be calculated by equations (2) to (16) while Equation (2) used to find odd and even row. Equations (3) and (4) define these.

$$h(j,k) = \begin{cases} f(j,k), & \text{if } j \text{ lies in odd rows} \\ g(j,k), & \text{if } j \text{ lies in even rows} \end{cases} \quad (2)$$

$$f(j,k) = \begin{cases} c1(j,k), & k \text{ has values } 1,4,7,9\ldots \\ c2(j,k), & k \text{ has values } 2,5,8,11\ldots \\ c3(j,k), & k \text{ has values } 3,6,9,12\ldots \end{cases} \quad (3)$$

$$g(j,k) = \begin{cases} c4(j,k), & k \text{ has values } 1,4,7,9,\ldots \\ c5(j,k), & k \text{ has values } 2,5,8,11\ldots \\ c6(j,k), & k \text{ has values } 3,6,9,12\ldots \end{cases} \quad (4)$$

$f(j,k)$ represents the odd position rows which will take values of different columns (columns of 1,4,7,... as one set, 2,5,8,... as another set, and 3,6,9,... as another set) as $c1(j,k)$, $c2(j,k)$ and $c3(j,k)$. Equations (5), (6) and (7) define these columns and the even position rows with value value $g(j,k)$ will take values of different columns (columns of 1,4,7,... as one set, 2,5,8,... as another set, and 3,6,9,... as another set) as $c4(j,k)$, $c5(j,k)$ and $c6(j,k)$ using the equations (8), (9) and (10) respectively.

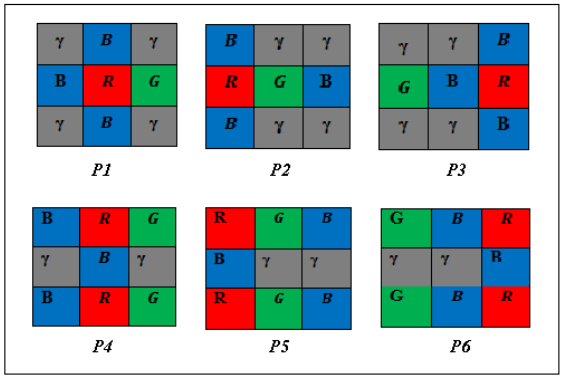

Figure 3: TCTP Patterns

$$d1(j,k) = \sum_{\beta=0}^{7} \begin{cases} 2^{\beta}, & \text{if } (p1(\beta) - v_1(j,k)) > 0 \\ 0, & \text{otherwise} \end{cases} \quad (5)$$

$$d2(j,k) = \sum_{\beta=0}^{7} \begin{cases} 2^{\beta}, & \text{if } (p2(\beta) - v_2(j,k)) > 0 \\ 0, & \text{otherwise} \end{cases} \quad (6)$$

$$d3(j,k) = \sum_{\beta=0}^{7} \begin{cases} 2^{\beta}, & \text{if } (p3(\beta) - v_3(j,k)) > 0 \\ 0, & \text{otherwise} \end{cases} \quad (7)$$

$$d4(j,k) = \sum_{\beta=0}^{7} \begin{cases} 2^{\beta}, & \text{if } (p4(\beta) - v_4(j,k)) > 0 \\ 0, & \text{otherwise} \end{cases} \quad (8)$$

$$d5(j,k) = \sum_{\beta=0}^{7} \begin{cases} 2^{\beta}, & \text{if } (p5(\beta) - v_5(j,k)) > 0 \\ 0, & \text{otherwise} \end{cases} \quad (9)$$

$$d6(j,k) = \sum_{\beta=0}^{7} \begin{cases} 2^{\beta}, & \text{if } (p6(\beta) - v_6(j,k)) > 0 \\ 0, & \text{otherwise} \end{cases} \quad (9)$$

Red component value is used as $v_1(j,k)$, green component value is considered as $v_2(j,k)$, blue component value is used $v_3(j,k)$ and blue component value is used as $v_4(j,k)$ in respective positions. But, $v_5(j,k)$ will be α value and $v_6(j,k)$ will also be α value. β will have values from 0 to 7. The α value will be considered to be zero. GBR, RGB and BRG planes are used for calculating three different patterns. Nine pattern formation I given in Figure 1 and example of that for a block of 7X6 is given in Figure 2. Equations (11) to (16) provide the values $p1(\beta)$, $p2(\beta)$, $p3(\beta)$, $p4(\beta)$, $p5(\beta)$ and $p6(\beta)$. Other patterns can be calculated by replacing color values.

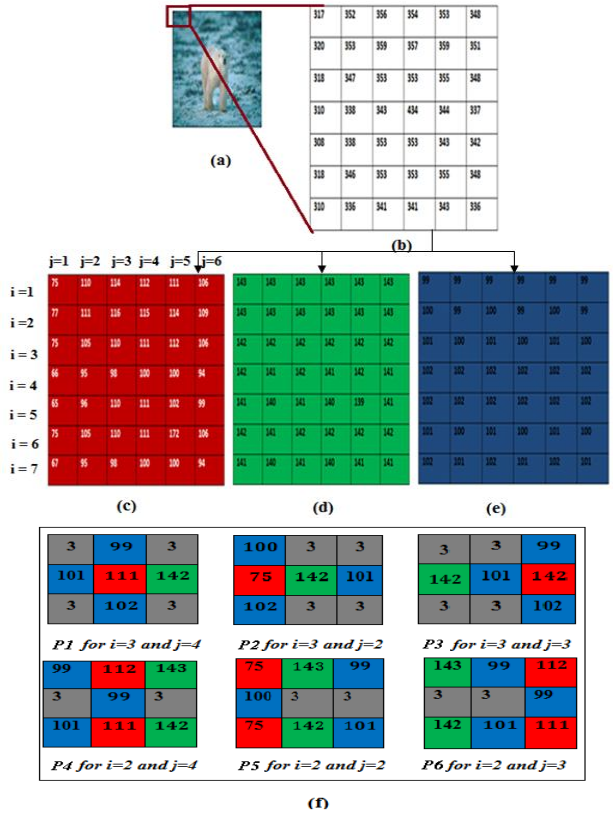

Figure 4: Example for TCTP pattern sequence extraction

$$p2(\beta)_{c_1c_2c_3} = [\alpha, c_{3_{r-1,c}}, \alpha, c_{2_{r,c+1}}, \alpha, c_{3_{r,c+1}}, \alpha, c_{3_{r,c-1}}] \quad (11)$$

$$p2(\beta)_{c_1c_2c_3} = [c_{2_{r-1,c-1}}, \alpha, \alpha, c_{3_{r,c-1}}, \alpha, \alpha, c_{3_{r+1,c-1}}, c_{1_{r,c-1}}] \quad (12)$$

$$p2(\beta)_{c_1c_2c_3} = [\alpha, \alpha, c_{3_{r-1,c+1}}, c_{1_{r,c+1}}, c_{2_{r+1,c+1}}, \alpha, \alpha, c_{2_{r,c-1}}] \quad (13)$$

$$p2(\beta)_{c_1c_2c_3} = [c_{3_{r-1,c-1}}, c_{1_{r-1,c}}, c_{2_{r-1,c+1}}, \alpha, c_{2_{r+1,c+1}}, c_{1_{r+1,c}}, c_{3_{r+1,c-1}}, \alpha] \quad (14)$$

$$p2(\beta)_{c_1c_2c_3} = [c_{1_{r-1,c-1}}, c_{2_{r-1,c}}, c_{3_{r-1,c+1}}, \alpha, c_{3_{r+1,c+1}}, c_{2_{r+1,c}}, c_{1_{r+1,c-1}}, c_{3_{r,c-1}}] \quad (15)$$

$$p2(\beta)_{c_1c_2c_3} = [c_{2_{r-1,c-1}}, c_{3_{r-1,c}}, c_{1_{r-1,c+1}}, c_{3_{r,c+1}}, c_{1_{r+1,c+1}}, c_{3_{r+1,c}}, c_{2_{r+1,c-1}}, \alpha] \quad (16)$$

This pattern is calculated for database and query images and which will be used for detecting the person.

3. RESULTS AND DISCUSSIONS

Figure 5: Example images from Indian Faces database

Indian Faces database [48] is a dataset with 50 persons. Each person will have 10 sample images. This is published by IIT Kanpur in India. All the images are taken in different orientations [49-53]. In this, 25 are males and 25 are females. 240 expressions are used for testing with different orientations of 180º or lesser. Figure 5 gives example images.

The performance analysis is done between proposed work other works. We used LTrP, LBP and LOCTP. The described figures and table give the analysis.

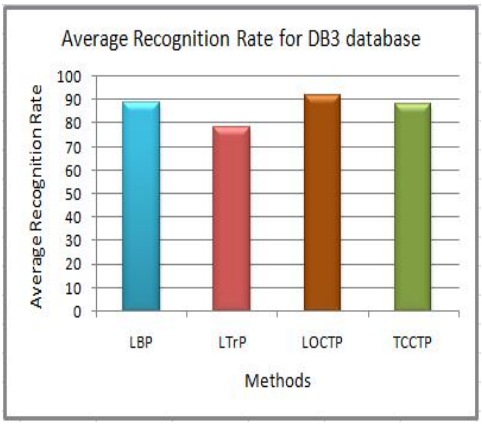

Figure 6: ARR for dataset

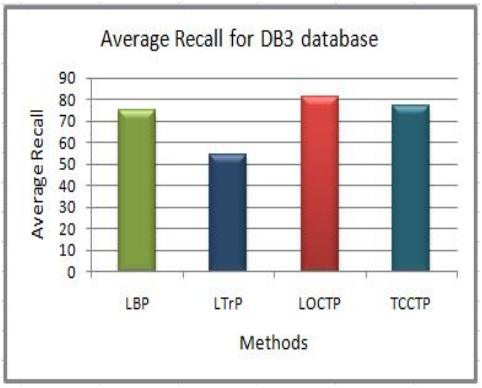

Figure 7: Average recall for dataset

Table 1: Performance evaluation in terms of Average Precision

Works				
LOCTP [49]	88.6	77.9	70.7	63.7
LBP [50]	76.2	60.5	53.3	47.8
LTrP [51]	89.9	81.05	73.1	66.62
Proposed work	88.7	78.05	71.77	61.82

Average retrieval rate (ARR) is used for comparison which is given in Figure 6. Analysis in terms of average recall (AR) is given in Figure 7. Table 1 gives the analysis in terms of average precision (AP).

4. CONCLUSION

The proposed work is aiming at recognizing face images. The chromatic-texture descriptor is used to get the relevant feature. Since the opponent color channel is used to retrieve the features, human color vision is imparted into the system because of opponent color theory. The results show better results than many other previous works.

REFERENCES

1. L. Zhi-fang, Y. Zhi-sheng, A.K.Jain and W. Yun-qiong, 2003, "**Face Detection And Facial Feature Extraction In Color Image**", Proc. The Fifth International Conference on Computational Intelligence and Multimedia Applications (ICCIMA'03), pp.126-130, Xi'an, China.

2. J. Ruan and J. Yin, 2009, "**Face Detection Based On Facial Features And Linear Support Vector Machines**", Proc. 2009 International Conference on Communication Software and Networks, pp.371-375, Macau, China..
https://doi.org/10.1109/ICCSN.2009.76

3. L. Zhao, X. Sun and X. Xu, 2006, "**Face Detection Based On Facial Features**", Proc. ICSP2006, Guilin, China
https://doi.org/10.1109/ICOSP.2006.345820

4.. K. Seo, W. Kim, C. Oh and J. Lee, 2002, "**Face Detection And Facial Feature Extraction Using Color Snake**", Proc. ISIE 2002 - 2002 IEEE International Symposium on Industrial Electronics, pp.457-462, L 'Aquila, Italy

5. C. Lin, 2005, "**Face Detection By Color And Multilayer Feedforward Neural Network**", Proc. 2005 IEEE International Conference on Information Acquisition, pp.518-523, Hong Kong and Macau, China.

6. S. Kherchaoui and A. Houacine, 2010, "**Face Detection Based On A Model Of The Skin Color With Constraints And Template Matching**", Proc. 2010 International Conference on Machine and Web Intelligence, pp. 469 - 472, Algiers, Algeria.
https://doi.org/10.1109/ICMWI.2010.5648043

7. Chengdu, China. Z. Li, L. Xue and F. Tan, 2010, "**Face Detection In Complex Background Based On Skin Color Features And Improved Adaboost Algorithms**", Proc. 2010 IEEE International Conference on Progress in Informatics and Computing (PIC), pp.723 – 727, Shanghai, China.

8. D. Huang, T. Lin, C. Ho and W. Hu, 2010, "**Face Detection Based On Feature Analysis And Edge Detection Against Skin Color-like Backgrounds**", Proc. 2010 Fourth International Conference on Genetic and Evolutionary Computing, pp.687-690, Shenzen, China.

9. M. A. Berbar, H. M. Kelash and A. A. Kandeel, 2006, "**Faces And Facial Features Detection In Color Images**", Proc. Geometric Modeling and Imaging— New Trends (GMAI'06), pp.209-214, London, UK.

10. J. Qiang-rong and L. Hua-lan, 2010, "**Robust Human Face Detection in Complicated Color Images**", Proc. 2010 The 2nd IEEE International Conference on Information Management and Engineering (ICIME), pp.218 – 221.

11. C. Aiping, P. Lian, T. Yaobin and N. Ning, 2010, "**Face Detection Technology Based On Skin Color Segmentation And Template Matching**", Proc. 2010 Second International Workshop on Education Technology and Computer Science, pp.708-711, Wuhan, China.
https://doi.org/10.1109/ETCS.2010.465

12. P. Peer, J. Kovac and F. Solina, 2003, "**Robust Human Face Detection in Complicated Color Images**", Proc. 2010 The 2nd IEEE International Conference on Information Management and Engineering (ICIME), pp. 218 – 221, Chengdu, China.

13. Y. Kun, Z. Hong and P. Ying-jie, 2006, "**Human Face Detection Based On SOFM Neural Network**", Proc. 2006 IEEE International Conference on Information Acquisition, pp.1253-1257, Weihai, Shandong, China.

14. H. Guo, Y. Yu and Q. Jia, 2010, "**Face Detection With Abstract Template**", Proc. 2010 3rd International Congress on Image and Signal Processing (CISP2010), pp.129-134, Yantai, China

15. W. Chen, T. Sun, X. Yang and L. Wang, 2009, "**Face Detection Based On Half Face-Template**", Proc. The Ninth International Conference on Electronic Measurement & Instruments ICEMI'2009, pp. 4-54-4-59, Beijing, China.
https://doi.org/10.1109/ICEMI.2009.5274642

16. A. R. Mohan and N. Sudha, 2009, "**Fast Face Detection Using Boosted Eigenfaces**", Proc. 2009 IEEE Symposium on Industrial Electronics and Applications (ISIEA 2009), pp.102-1006, Kuala Lumpur, Malaysia.
17. J. Wang and H. Yang, 2008, "**Face Detection Based On Template Matching And 2DPCA Algorithm**", Proc. 2008 Congress on Image and Signal Processing, pp.575-579, Hainan, China.
18. D. Anijiantis, E. Dernzatas and G. Kukkinakis, 1999, "**A Neural Network Method For Accurate Face Detection On Arbitrary Images**", Proc. The 6th IEEE International Conference on Electronics, Circuits and Systems, pp. 109 - 112 vol.1, Pafos, Cyprus.
19. M. Ş. Bayhan and M. Gökmen, 2008, "**Scale And Pose Invariant Real-Time Face Detection And Tracking**", Proc. 23rd International Symposium on Computer and Information Sciences ISCIS '08, pp.1-6, Istanbul, Turkey.
https://doi.org/10.1109/ISCIS.2008.4717941
20. C. Anagnostopoulos, I. Anagnostopoulos, D. Vergados, I. Papaleonidopoulos, E. Kayafas, V. Loumos and G. Stasinopoulos, 2002, "**A Probabilistic Neural Network For Face Detection On Segmented Skin Areas Based On Fuzzy Rules**", Proc. IEEE MELECON 2002, pp.493-497, Cairo, Egypt.
21. C.C. Tsai, W.C. Cheng, J.S. Taur and C.W. Tao, 2006, "**Face Detection Using Eigenface And Neural Network**", Proc. 2006 IEEE International Conference on Systems, Man, and Cybernetics, pp.4343-4347, Taipei, Taiwan.
22. W. Wang, Y. Gao, S. C. Hui and M. K. Leung, 2002, "**A Fast And Robust Algorithm For Face Detection And Localization**", Proc. 9th International Conference on Neural Information Processing (ICONIP'O2), pp.2118-2121, Orchid Country Club, Singapore.
23. K. A. A. Aziz and R. A. Ramlee, 2009, "**Face Detection Using Radial Basis Function Neural Networks With Variance Spread Value**", Proc. 2009 International Conference of Soft Computing and Pattern Recognition, pp.399403, Malacca, Malaysia.
24. M. Tayyab and M. F. Zafar, 2009, "**Face Detection Using 2D-Discrete Cosine Transform And Back Propagation Neural Network**", Proc. 2009 International Conference on Emerging Technologies, pp.35-39, Islamabad, Pakistan.
https://doi.org/10.1109/ICET.2009.5353205
25. Ye-Zhengchun and Lin-Hongji, 2007, "**Face Detection Based On SCNN And Wavelet Invariant Moment In Color Image**", Proc. 2007 International Conference on Wavelet Analysis and Pattern Recognition, pp. 783-787, Beijing, China.
26. X. Liu, G. Geng and X. Wang, 2010, "**Automatically Face Detection Based On BP Neural Network And Bayesian Decision**", Proc. 2010 Sixth International Conference on Natural Computation (ICNC 2010), pp.1590-1594, Shandong, China.
27. C. Shavers, R. Li and G. Lebby, 2006, "**An SVM-Based Approach To Face Detection**", Proc. 38th Southeastern Symposium on System Theory, pp.362-366, Tennessee Technological University, Cookeville, TN, USA.
28. Y. Song, Y. Kim, U. Chang and H. B. Kwon, 2006, "**Face Recognition Robust To Left-Right Shadows Facial Symmetry**", Pattern Recognition Vol.39 (2006), pp.1542–1545.
29 M. I. Razzak, M. K. Khan, K. Alghathbar and R. Yousaf, 2010, "**Face Recognition Using Layered Linear Discriminant Analysis And Small Subspace**", Proc. 2010 10th IEEE International Conference on Computer and Information Technology (CIT 2010), pp.1407-1412, West Yorkshire, UK.
30. F. Wang, J. Wang, C. Zhang and J, Kwok, 2007, "**Face Recognition Using Spectral Features**", Pattern Recognition Vol.40 (2007), pp.2786–2797.
https://doi.org/10.1016/j.patcog.2007.01.023
31. A.H.Boualleg, Ch.Bencheriet and H.Tebbikh, 2006, "**Automatic Face Recognition Using Neural Network-PCA**", Proc. 2nd Information and Communication Technologies ICTTA '06, pp. 1920 – 1925, Damascus, Syria.
32. . H. Jin, Q. Liu and H. Lu, 2004, "**Face detection using one-class-based support vectors**", Proc. Sixth IEEE International Conference on Automatic Face and Gesture Recognition (FGR'04), pp.457 - 462, Seoul, Korea.
33. G. Wang and Z. Ou, 2006, "**Face Recognition Based On Image Enhancement And Gabor Features**", Proc. 6th World Congress on Intelligent Control and Automation, pp.9761-9764, Dalian, China.
34. H. Jee, K. Lee and S. Pan, 2004, "**Eye And Face Detection Using SVM**", Proc. ISSNIP 2004, pp.577-580, Melbourne, Australia.
35. C. Liu and H. Wechsler, 2003, "**Independent Component Analysis Of Gabor Features For Face Recognition**", Proc. IEEE Transactions On Neural Networks, Vol. 14, pp.919-928.
36. K. Youssef and P. Woo, 2007, "**A New Method for Face Recognition Based on Color Information and a Neural Network**", Proc. Third International Conference on Natural Computation (ICNC 2007), pp.585 – 589, Hainan, China.
37. M.R.M. Rizk and A. Taha, 2002, "**Analysis Of Neural Networks For Face Recognition Systems With Feature Extraction To Develop An Eye Localization Based Method**", Proc. 9th International Conference on Electronics, Circuits and Systems, pp. 847 - 850 vol.3, Dubrovnik, Croatia
38. J. Youyi and L. Xiao, 2010, "**A Method For Face Recognition Based On Wavelet Neural Network**", Proc. 2010 Second WRI Global Congress on Intelligent Systems, pp.133-136, Wuhan, China.
https://doi.org/10.1109/GCIS.2010.242
39. W. Wang, 2008, "**Face Recognition Based On Radial Basis Function Neural Networks**", Proc. 2008 International Seminar on Future Information Technology and Management Engineering, pp.41-44, Leicestershire, UK.
40. Z. Mu-chun, 2008, "**Face Recognition Based On FastICA And RBF Neural Networks**", Proc. 2008 International Symposium on Information Science and Engineering, pp.588-592, Shanghai, China.
41. T. S. M. Rasied, O. O. Khalifa and Y. B. Kamarudin, 2005, "**Face Recognition Based On Singular Valued**

Decomposition And Back Propagation Neural Network", Proc. 1st International Conference on Computers, Communications, & Signal Processing with Special Track on Biomedical Engineering CCSP 2005, pp.304 – 309, Kuala Lumpur, Malaysia.

42. A. Rida and Dr BoukelifAoued, 2004, "**Artificial Neural Network-Based Face Recognition**", Proc. First International Symposium on Control, Communications and Signal Processing, pp.439 – 442, Hammamet, Tunisia.

43. D.N Pritha, L. Savitha and S.S. Shylaja, 2010, "**Face Recognition By Feedforward Neural Network Using Laplacian Of Gaussian Filter And Singular Value Decomposition**", Proc. 2010 First International Conference on Integrated Intelligent Computing, pp.56-61, Bangalore, India.
https://doi.org/10.1109/ICIIC.2010.8

44. Leo, HM & Dorothea, J (1957), "**An opponent-process theory of colour vision**", *Psychological Review*, vol.64, no.6, pp. 384–404.

45. Ching, HS, Huang-Sen Chiu & Tsai-Ming, H, "**An efficient image retrieval based on HSV colour space**", *International Conference on Electrical and Control Engineering*, (2011),pp. 5746 – 5749.

46. Drimbarean, A & Whelan, PF (2001), "**Experiments in colour texture analysis**", *Pattern Recognition Letters*, vol.22, no.1,pp. 1161–1167.

47. I.Jeena Jacob,.K.G.Srinivasagan,.S. Gomathi, P. Joyce Beryl Princess,.P.Betty,.P.Ebby Darney, "**Tri-Chrominance Texture Pattern: A New Feature Descriptor,**" International Journal of Engineering & Technology, vol.5, 2018.

48. Jain, V &Mukherji, Indian Face Database 2002. Available from:<http://vi-www.cs. umass.edu/ ~vidit/ IndianFaceDatabase>.

49. I. Jeena Jacob, K.G. Srinivasagan, K. Jayapriya, "**Local Oppugnant Color Texture Pattern for image retrieval system**," Pattern Recognition Letters, Volume 42, 2014, Pages 72–78.
https://doi.org/10.1016/j.patrec.2014.01.017

50. T. Ojala, M. Pietikainen, and T. Maenpaa, **"Multiresolution gray-scale and rotation invariant texture classification with local binary patterns**," IEEE Trans. Pattern Anal. Mach. Intell., Vol. 24, No. 7, pp. 971–987, Jul. 2002.

51. Subrahmanyam Murala, R. P. Maheshwari, and R. Balasubramanian," **Local Tetra Patterns: A New Feature Descriptor for Content-Based Image Retrieval**," IEEE Transactions on Image Processing, Vol. 21, No. 5,pp. 2874-2886, May. 2012.

52. Dr Nishad Nawaz, "**Artificial Intelligence Face Recognition for applicant tracking system**" International Journal of Emerging Trends in Engineering Research, Volume 7, No. 12, pp.895-901, December 2019

53. Dr..Usha Ruby,Dr.J.George Chellin Chandran "**Dominant Local Tetra Patterns: A New Feature Descriptor for Face Recognition** "International Journal of Emerging Trends in Engineering Research, 8(4), April 2020, 956 – 963
https://doi.org/10.30534/ijeter/2020/03842020