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Video Enhancement to Reduce Reflection and Darkness Caused by the Sunglasses using Fusion Algorithm

Divya A.K, Bhagya H.K, Ujwal U.J

***Abstract:** The enhancement of video of a person wearing sunglasses to reduce the reflection and darkness is a very challenging task in computer vision applications such as video surveillance. The existence of reflections and darkness caused by sunglasses results in intrusive images. The absence of a clear eye diminishes the visible quality of the complete face image. The eyes under sunglasses are not identified clearly if the reflection and darkness exist in the sunglasses. This paper demonstrates the reduction of adverse artifacts such as reflection and darkness in the eye region caused by sunglasses. The system is carried out with the fusion algorithm which consists of three modules: eyeglass tracking on face images, reduction of reflection, and reduction of darkness through the image enhancement method. The image enhancement method includes a color balance algorithm and a histogram stretching algorithm. Firstly, an automatic glasses presence detection model, based on a Robust Local Binary Pattern identifies the imaging process of the ocular region covered by the sunglasses. Secondly, a non-convex optimization scheme, guided by landmarks on the glasses, effectively reduces reflections through several iterations. The image enhancement method incorporating Color Balance, and Histogram Stretching is used to identify eye regions within sunglasses. The resulting regenerated eye regions within sunglasses exhibit increased brightness, subtle darkness, and minimized reflection. The objective evaluation metrics such as peak signal-to-noise ratio, structural similarity index measure, and logarithmic mean square error are used to measure the strength of the proposed system. Qualitative evaluations are conducted to demonstrate the good quality of eyeglass face images with reduced reflection and darkness.*

***Keywords:** Color balancing, Histogram Stretching, Non-convex Optimization, Robust Local Binary Pattern.*

I. INTRODUCTION

Enhancing videos has long been a focal point in specific and dominant regions, aiming not only to improve visual aesthetics but also to optimize performance in terminal tasks. The visible quality of the degraded footage is improved using video improvement techniques.

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**Correspondence Author(s)*

Divya A K*, Department of Computer Science & Engineering, KVG College of Engineering, Sullia, VTU Belagavi, Sullia (Karnataka), India. E-mail: divyaak11@gmail.com, ORCID ID: 0009-0008-1921-3686

Dr. Bhagya H K, Department of Electronics and Communication Engineering, KVG College of Engineering Sullia, VTU Belagavi, Sullia (Karnataka), India. E-mail: bhagyahk74@gmail.com

Dr. Ujwal U J, Department of Computer Science & Engineering, KVG College of Engineering, Sullia, VTU Belagavi, Sullia (Karnataka), India. E-mail: ujwalu@yahoo.com

The most active study areas in computer vision and pattern recognition [2] over the last ten years are statistical learning-based methods that have been applied to face analysis and synthesis. The common techniques for face identification and detection are eigenface [3], neural networks [4]-[5] [22][23][24], and support vector machines [6]. Even though many individuals wear glasses, the majority of approaches require extracting facial features like the eyebrows, and nose using a non-glasses assumption on human faces. It is crucial to examine sunglasses for face detection, recognition, and synthesis since it might be challenging to study a person wearing glasses if a "facial detector training" approach is utilized or if it is misidentified by an identification system. People avoided dealing with sunglasses in facial identification systems for some reason. First, different material qualities [17], such as those of metal and plastic, present the distinctive appearance of glass frames. Second, unlike human skin, glasses have quite different reflective qualities. In certain cases, the reflection on the glasses is the brightest part of the face. Third, while glasses are always adhered to the face and blended with eyebrows, faces are always clearly differentiated from backgrounds. Thus, eyewear detection may not benefit from tracking approaches.

Effective mechanisms for the reduction of reflection and darkness in sunglass images are still a major challenge. Only minimal research works are done on eyeglasses for the reduction of reflection and darkness. The eye regions of the individual wearing sunglasses are invisible in the video, and they cannot be distinguished. Because of darkness of the sunglasses, the eye areas will be dark. Only a part of light passes through sunglasses when it is incident on them. The area around the eye region will darken for this reason. Additionally, the sunglasses are highly reflective. Such reflection further lowers the video quality. By covering the glasses with an anti-glare material [18], these problems can be fixed. It might, however, cost more than a pair of sunglasses. Overall, improving video quality by reducing reflection and darkness poses a significant challenge, yet it is imperative for advancing overall video quality. Enhancing video clarity by mitigating darkness and reflection presents a progressing challenge that needs effective strategies, particularly in identifying individuals wearing dark eyewear.

The proposed system requires a dataset that provides person faces with sunglasses. As this problem is rarely investigated in current literature, it is very difficult to find some publicly available face databases.

The proposed system demonstrated 100 real-time databases of people wearing sunglasses. This database includes facial images with a variety of sunglasses with different ranges of reflection and darkness. Evaluations and user research show a significant improvement in the quality of the images with the sunglasses.

II. LITERATURE REVIEW

Work involving eyewear photos and videos has been rare. The majority of studies have been conducted on the recognition, localization, and removal of spectacles. Wu et al. [7] study, which sought to automatically remove eyeglasses in facial photos, is among the most intriguing ones. It uses a boosting-based algorithm to find eyeglasses. The removal of eyeglasses is then done using a statistical analysis and synthesis approach based on training data. With training samples set, it is challenging to model the reflection using this method. Additionally, this method struggles with strong reflections. Yuan-Kai Wang et al. [8] introduce the Active Appearance Model (AAM) to eliminate eyeglasses from facial images. The locations where glasses occlude are found via an AAM search. The ellipse model fits the location of the eyes, and then the adaptive threshold method is adapted to enhance and remove the residual regions. The Principal Component Analysis (PCA) reconstruction method by J-S Park et al. [9] is utilized to remove the eyeglasses from the facial images to generate natural-looking facial images. It removes various types of occlusions caused by eyeglasses. Liang et al. [10][25] applied the CTV (Color Total Variation) inpainting approach for the reconstruction of the glass region. The noises from glasses can be reduced by the Deep Learning approach.

The efficiency of eye detection is compromised by secondary image forms, glare, and spectacle occlusion. Using an in-depth analysis strategy, M Z Lazarus and S Gupta [11] suggested a Low-Rank Decomposition method to remove the glare and spectacle reflections. In this instance, the face alignment is typically not accurate. A non-convex optimization scheme by Tushar Sandhan, and Jin Young Choi [12] removes the reflections from eyeglasses. The experiment is done on frontal face image inputs, resulting in high-quality reflection removal and improving the iris detection rate. Mao Ye et al. [1] presented a technique to reduce the undesirable artifacts caused by 3D glasses. A Bayesian model is utilized to reduce the reflection and darkness from 3D glass images. The eye regions under glasses are identified by the Classification Expectation-Maximization method.

The underwater image dehazing algorithm introduced by Yu et al. [14] combines three main steps of homomorphic filtering, double transmission map, and dual-image wavelet fusion, used to intensify the underwater image. Real-world Underwater Image Enhancement (RUIE) by R.Liu et al. [15] evaluates the effectiveness and limitations of various algorithms to enhance visibility and correct color cast on images with hierarchical categories of degradation. A novel approach by O.G.Powar [16] to enhance underwater images by distance factor estimation along with a dehazing algorithm and histogram equalization, the dark channel prior to removing haze and noise effect, adaptive histogram equalization brightness of dehazed image is recovered. A fusion algorithm introduced by Weilin Luo et al. [13] with color balance, and histogram stretching is implemented for the enhancement of underwater images.

III. PROPOSED METHODOLOGY

The proposed system lightens and reduces reflection from sunglass images. This proposed framework is implemented with a fusion algorithm which includes tracking the position of sunglasses, reflection reduction, and image enhancement for the reduction of darkness as shown in Figure 1. It focuses on the frontal face without any facial expressions and our aim for the reduction of reflection and darkness to identify the eye region under sunglasses. This work includes three steps. First, track the position of the sunglass on face images. For such purpose, a model-based Robust Local Binary Pattern is developed. Second, a model that uses a non-convex optimization approach is used to reduce the reflection. Third, Color Balance, and Histogram Stretching are adapted to enhance the image to identify the eye region within sunglasses. Finally, the enhanced frame is regenerated with reduced reflection and darkness.

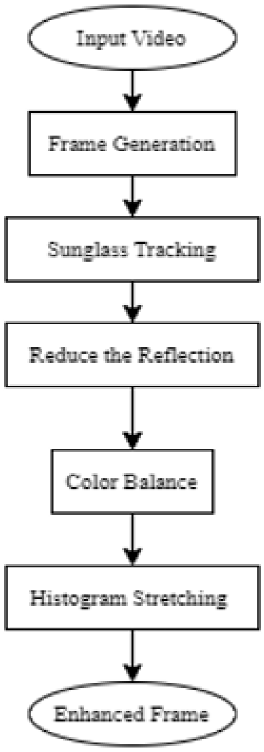

Fig. 1. Architectural of Proposed Method

A. *Sunglass Tracking*

The reliable measurement of eye shape or intensity characteristics is hindered by factors like wearing glasses or sunglasses. However, context features prove highly valuable for localizing eyes because they maintain firm relationships with other facial features in appearance and structural distribution. Initially, a face normalization algorithm is employed to isolate the eye region. Subsequently, LBP (Local Binary Patterns) and Robust LBP techniques are utilized to extract feature sets.

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The eight facial landmarks are recognized using this method. Four points are used to create a regression line to find the alignment angle: the left outer eye, left inner eye, right outer eye, and right inner eye. The faces in each image are then aligned and rotated to ensure that the eyes are in the same location in each image. Then, in the original image, the area surrounding the eyes is computed. The corresponding area is cropped from the rotated image after the coordinates for the corners of the eyewear region are found. Finally, a Support Vector Machine (SVM) is employed for classification. The SVM categorizes extracted feature histograms from normalized eye regions into two classes: glasses and no glasses. Thus, various types of glasses (e.g., sunglasses, sports glasses, reading glasses, safety glasses) are treated as belonging to the same category. SVMs are recognized for their efficiency in data classification and have demonstrated utility across various pattern recognition approaches, including facial recognition.

B. Non-Convex Optimization

The lack of clear visibility of the eyes not only diminishes the aesthetic appeal of a full-face image but also faces challenges for various computer vision problems. Even minor reflections can result in an unwanted overlay of visual information. In contrast to the thick and flat window glass, eyeglasses are thin, curved, and made from a variety of materials. An Anti-Reflective Coating (ARC), a transparent thin film, is applied to eyeglass lenses to enhance light transmission and reduce surface reflectance. The fundamental operation of ARC is represented in Figure 2.

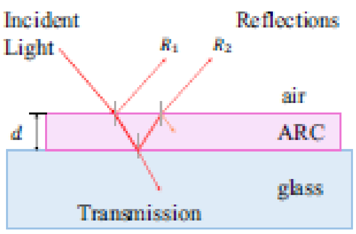

Fig.2. Anti-Reflective Coating

Since α<1, for a fixed I_{R_t}, z_j can be updated for each pixel as,

$$z_{t+1}^{j} = argmin_{z^j}\left\{\left|z^j\right|^{\alpha} + \frac{\beta}{2}\left(z^j - D_i^j\, I_{R_t}\right)^2\right\} \tag{1}$$

where z_t^j is the auxiliary variable at each pixel.

Since this is a single variable optimization problem, it can be rapidly solved by using a lookup table-based implementation, which maps the values from $D_i^j\, I_{R_t}$ to z^j. We fill the Look Up Table (LUT) by generating 104 different gradient values between -0.4 to 0.4, for α = 0.6 and various β. If the required value is missing from LUT then it is found via interpolation.

We further apply 2D FFT $\mathcal{F}$ to find the optimal update I_{R_t} quickly as given below in (2), where ϵ (= 10-16) avoids division by 0, $\overline{\mathcal{F}(.)}$ is a complex conjugate $\mathcal{F}(.)$, $\bar{1}$ is a vector as same size as I and having all elements as 1, o denotes element-wise multiplication and division in (2) is also performed element-wise. Only $\mathcal{F}(z_t^j)$ is computed at each iteration, whereas the rest of the terms are precomputed once.

$$I_{R_t} = \mathcal{F}^{-1}\left(\frac{\lambda\sum_{j\in\mathbb{J}_\beta}\overline{\mathcal{F}(D^j)}\circ\mathcal{F}(D^j)\circ\mathcal{F}(I) + \beta\sum_{j\in\mathbb{J}_R}\overline{\mathcal{F}(D^j)}\circ\mathcal{F}(Z_t^j) + \gamma\mathcal{F}\left(\widetilde{W_{af}^T}\widetilde{W_{af}}I\right)}{\lambda\sum_{j\in\mathbb{J}_\beta}\overline{\mathcal{F}(D^j)}\circ\mathcal{F}(D^j) + \beta\sum_{j\in\mathbb{J}_R}\overline{\mathcal{F}(D^j)}\circ\mathcal{F}(D^j) + \gamma\mathcal{F}\left(\widetilde{W_{af}^T}\widetilde{W_{af}}\bar{1}\right) + \epsilon}\right) \tag{2}$$

Constraints can be satisfied by adding the adaptive normalizing constant ξ to I_{R_t} at each iteration such that (ξ + $I_{R_t}[i]$) falls within $[\kappa\Gamma_t[i],\ I[i]]$. The ξ can be derived by solving the following,

$$min_{\zeta}\sum_{i}\mathcal{U}(\xi + I_{R_t}[i] - I[t])^2 + \mathcal{U}(\kappa\Gamma_t[i] - \xi - I_{R_t}[i])^2 \tag{3}$$

where $\mathcal{U}(x)$ is the general unit step function (i.e. $\mathcal{U}(x) = 1\ \forall_x > 0\ otherwise\ \mathcal{U}(x) = 0$), which penalizes only those elements that violate the constraints. After solving (3) by simple gradient descent, we update I_{R_t} for all i as $I_{R_t}[i] = \xi + I_{R_t}[i]$. Algorithm 1 summarizes the whole optimization scheme for the reduction of eyeglass reflection.

Algorithm 1 An Optimization Framework

Input: input image I; optimization weights λ, γ; total number of iterations T
Initialize: $I_{R_0} \leftarrow I$, $\beta = \beta_0$
For iteration t from 1 to T do
  Update Z_t^j using (1)
  Update I_{R_t} using (2)
  $\beta = 2\beta$, $K = \frac{t}{T}$
  Update $I_{R_t} = I_{R_t} + \varepsilon\bar{1}$ using (3)
Output: reflection reduced image $(I - I_{R_t})$

C. The Fusion Algorithm

In enhancing the sunglass region, a fusion algorithm is utilized, which combines color balancing and histogram stretching. To counteract any color shifts in the image, scalar values of the Red, Green, and Blue channels are updated. Additionally, a technique known as "histogram stretching" on the red channel is applied to enhance the contrast and brightness of the images.

To mitigate color shift effects, a color balance algorithm is introduced. This algorithm ensures that the histogram's single channel values in each color channel of an image are adjusted to align at comparable positions. This approach begins by computing the average single channel values for the three components: Red, Green, and Blue, denoted as m_R, m_G, and m_B, respectively.

Next, the average scalar value of the mean single channel values from the Red (R), Green (G), and Blue (B) channels can be derived as follows:

$$m_{ave} = \frac{(m_R + m_G + m_B)}{3} \tag{4}$$

The difference between the average single channel m_R, m_G, m_B, and the mean scalar value m_{ave} can be calculated as:

$$\begin{cases} d_R = m_{ave} - m_R \\ d_G = m_{ave} - m_G \\ d_B = m_{ave} - m_B \end{cases} \tag{5}$$

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Ultimately, the single channel values of the red, green and blue channels can be adjusted to align at similar positions through:

$$\begin{cases} R' &= R + d_R \\ G' &= R + d_G \\ B' &= R + d_B \end{cases} \quad (6)$$

where R’, G’, and B’ represent the pixel values of the R, G, and B channel components of the processed image, respectively.

To enhance the contrast and brightness of an image, histogram stretching is performed [26][27]. A common issue encountered with many image enhancement algorithms is the tendency for excessive compensation in the red channel. In this approach, a histogram stretching algorithm specifically tailored to the red channel is introduced. This algorithm adjusts the histogram stretching process based on the intensity of red light. A scalar value threshold, denoted as R, is established to assess the depletion of red light. Initially, the average single channel value, denoted as R_{ave}, of the red channel, is calculated as:

$$R_{ave} = \frac{1}{n}\sum_{1}^{n} R_i \quad (7)$$

where R_i is the single channel value of every pixel, and n is the total number of pixels.

Next, R_{ave} is compared to the threshold R to assess the depletion of red light. If $R_{ave} \geq R$, the depletion of red light is considered minimal. Conversely, if $R_{ave} < R$, the depletion of red light is deemed significant. In the event of minimal depletion, histogram stretching is applied to all three channels: R, G, and B. However, when the depletion of red light is significant, histogram stretching is solely applied to the G and B channels, leaving the R channel unaltered to avoid overcompensation.

The histogram stretching accepts the algorithm as:

$$I_{new}^{c}(i,j) = \begin{cases} 0 & I_{old}^{c}(i,j) < i_{min}^{c} \\ 255 \times \dfrac{I_{old}^{c}(i,j) - i_{min}^{c}}{i_{max}^{c} - i_{min}^{c}} & i_{min}^{c} \leq I_{old}^{c}(i,j) \leq i_{max}^{c} \\ 255 & I_{old}^{c}(i,j) > i_{max}^{c} \end{cases} \quad (8)$$

where c is with R, G, B channels if $R_{ave} \geq R$, while G, B channels if $R_{ave} < R$; i_{min} the minimal value; i_{max} the maximal scalar value; $I_{new}^{c}(i,j)$ represents the updated scalar value at pixel point (i, j) after the histogram is stretched; $I_{old}^{c}(i,j)$ is the original scalar value at the same point. Both the minimal i_{min} and maximal i_{max} scalar values are determined through a threshold of pixel number ht. The satisfactory threshold h_t is selected as n×0.255% by trials.

IV. RESULT AND DISCUSSION

Three algorithms are introduced to address images of individuals wearing sunglasses. Initially, Robust LBP with SVM is employed to locate the regions of sunglasses in facial images. Subsequently, a non-convex optimization algorithm is utilized to mitigate reflections. Lastly, histogram stretching, focusing on the red channel, is implemented to enhance the brightness and contrast of the sunglass images.

Results are presented in Figure 3. The images under different brightness levels are considered. Figure 3a is the input image with reflection and darkness. Figure 3b gives the result of the processed method which is the clear enhanced image. The images with more reflection as in image 1 and image 4 result in poor performance. The images with less reflection as in image 1, image 5, and image 7 result in good performance.

1

2

3

4

5

6

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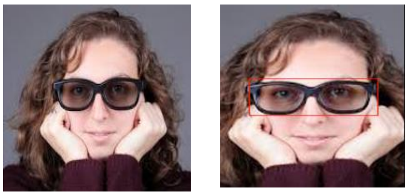
7



(a) (b)

Fig. 3. Results of Various Sunglass Images. (a) Input Images, (b) Enhanced Images

As human subjective consciousness can affect the assessment of visual effects, objective evaluation becomes essential to authenticate the enhancement techniques implemented in image processing. The study employs several classic objective evaluation metrics, namely PSNR (Peak Signal-to-Noise Ratio), SSIM (Structural Similarity), and LMSE (Logarithmic Mean Square Error). Typically, higher contrast correlates with better image quality. In this study, RMS contrast is utilized and takes the following form:

$$\sigma_{I_{w\times h}} = \sqrt{\frac{1}{w\times h}\sum\left(I(x,y) - \frac{1}{w\times h}\sum I(x,y)\right)^2} \quad (9)$$

where $\sigma_{I_{w\times h}}$ is the RMS contrast of an image with the dimension of $w \times h$; $I(x,y)$ is the pixel value at the point (x, y). Peak Signal-to-Noise Ratio (PSNR) [19] stands as a widely adopted objective measure for image assessment, relying on pixel error analysis. A correlated error sensitivity can be established to gauge the satisfaction level of processing outcomes. Less distortion is indicated by a higher PSNR value. The formulation of PSNR can be expressed as:

$$MSE = \frac{1}{w\times h}\sum_{i=0}^{w-1}\sum_{j=0}^{h-1}[I(i,j) - K(i,j)]^2 \quad (10)$$

$$PSNR = 10 \times \log_{10}\left(\frac{(2^n - 1)^2}{MSE}\right) \quad (11)$$

where I is a processed image with the dimension $w \times h$ while K is the original image with the same dimension. MSE represents the loss function. N represents the number of bits per pixel, usually considered as 8. Structural Similarity Index Measure (SSIM) [20] serves as an index for assessing the similarity between two digital images. Generally, a higher SSIM value indicates lesser distortion in the image. It relies on three comparison metrics between images x and y: luminance (l), contrast (c), and structure (s).

$$SSIM(x,y) = l(x,y)c(x,y)s(x,y) \quad (12)$$

Logarithmic Mean Square Error (LMSE) [21] is a metric for assessing the quality of images, which calculates the difference between two images. It is useful for images with a dynamic range, such as in high dynamic range imaging. LMSE is designed to reflect the logarithmic nature of human visual perception, where the human eye perceives differences in brightness logarithmically rather than linearly. Zero LMSE indicates perfect similarity between the images. It increases with a greater difference. LMSE is formulated as follows:

$$LMSE = \frac{1}{N}\sum_x\left(I_{log}^{ref}(x) - I_{log}^{dist}(x)\right)^2 \quad (13)$$

Where N represents the total number of pixels, I_{log}^{ref} is the transformed reference, and I_{log}^{dist} is the transformed distorted image. Table 1 presents the evaluation metric results obtained through PSNR, SSIM, and LMSE for seven images analyzed to assess visual effects. Generally, it is noted that the proposed method demonstrates superior performance.

Table I. The Processed Image Evaluated by Metric PSNR, SSIM, and LMSE

Input Images	Proposed PSNR	SSIM	LMSE
1	26.361	0.5673	0.435
2	19.6782	0.8542	0.245
3	24.9471	0.6892	0.410
4	22.056	0.8834	0.205
5	27.302	0.5342	0.453
6	25.2046	0.5672	0.437
7	30.4849	0.7437	0.492

V. CONCLUSION

A Fusion algorithm including RLBT, Non-convex Optimization, Color Balance, and Contrast Stretching is proposed to reduce the reflection and darkness present in the sunglass images. RLBT including SVM identifies the region of the sunglasses on face images. The reflection present over the sunglass is reduced by the Non-convex Optimization technique. The Color Balance and Contrast Stretching techniques enhance the sunglass region by the brightness level. The result of the proposed method is the enhanced image where we identify the eye region within the sunglasses. This experiment improves the visual quality of sunglasses. The experiments state the effectiveness of the proposed method. In addition to visual effect assessment, objective metrics such as PSNR, SSIM, and LMSE are employed to gauge the efficiency and strengths of the proposed fusion algorithm. The algorithm proposed here demonstrates superior enhancement compared to others. Ensuring real-time performance, particularly when handling sunglass images with high levels of reflection and darkness, cannot be guaranteed. Future endeavors will focus on refining the algorithm to fully eliminate reflection and darkness while also improving its real-time performance.

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REFERENCES

1. Mao. Ye, Cha Zhang, and Ruigang Yang, "Video Enhancement of People Wearing Polarized Glasses: Darkening Reversal and Reflection Reduction", IEEE Conference on Computer Vision and Pattern Recognition, 2013.
2. C. M. Bishop, Pattern Recognition and Machine Learning, Springer-Verlag New York, Inc., Secaucus, NJ, USA, 2006.
3. M.Turk, and A. Pentland, "Eigenface for Recognition", Journal of Cognitive Neurosciences, pp. 71–86, 1991. https://doi.org/10.1162/jocn.1991.3.1.71
4. H.Rowley, S.Baluja, and T.Kanade, "Neural Network-Based Face Detection", IEEE Transactions on PAMI, 20(1), 1998. https://doi.org/10.1109/34.655647
5. K.K. Sung, and T.Poggio, "Example-based Learning for View-based Human Face Detection", IEEE Transactions on PAMI, 20(1), pp. 39–51, 1998. https://doi.org/10.1109/34.655648
6. E.Osuna, R. Freund, and F.Girosi, "Training Support Vector Machines: An Application to Face Detection", Proc. of CVPR, pp. 130–136, 1997.
7. C. Wu, C. Liu, H.Y. Shum, Y.Q Xu, and Z. Zhang, "Automatic eyeglasses removal from face images", PAMI, 26(3), pp. 322–336, 2004. https://doi.org/10.1109/TPAMI.2004.1262319
8. Y. K.Wang, J.H. Janh, L.W. Tsai, and K.C. Fan, "Improvement of Face Recognition by Eyeglasses Removal", Sixth International Conference on Intelligent Information Hiding and Multimedia Signal Processing, 2010. https://doi.org/10.1109/IIHMSP.2010.64
9. J.S.Park, Y.H.oh, S.C.Ahn, and S.W.Lee, "Glasses removal from Facial Image Using Recursive Error Compensation", IEEE Transaction on Pattern Machine Intelligence, Vol. 27, No. 5, 2005. https://doi.org/10.1109/TPAMI.2005.103
10. A.F.Villan, R.Garcia, R.Usamentiaga, and R.Casado, "Glasses Detection on Real Images Based on Robust Alignment", Machine Vision and Applications 26 (4), pp. 1–13, 2015. https://doi.org/10.1007/s00138-015-0674-1
11. M.Z.Lazarus, and S.Gupta, "A Low-Rank model based Improved Eye Detection under Spectacles", IEEE 7th Annual Ubiquitous Computing, Electronics & Mobile Communication Conference, 2016. https://doi.org/10.1109/UEMCON.2016.7777820
12. Tushar Sandhan, and Jin Young Choi, "Anti-Glare: Tightly Constrained Optimization for Eyeglass Reflection Removal", IEEE Conference on Computer Vision and Pattern Recognition, 2017. https://doi.org/10.1109/CVPR.2017.182
13. Weilin Luo, Shunquiang, and Jiwen Zheng, "Underwater Image Restoration and Enhancement Based on a Fusion Algorithm with Color Balance, Contrast Optimization, and Histogram Stretching", IEEE Access, 9, pp. 31792-31804, 2021. https://doi.org/10.1109/ACCESS.2021.3060947
14. Yu, Haifeng & Li, Xinbin & Lou, Qian & Lei, Chengbo & Liu, Zhixin, "Underwater image enhancement based on DCP and depth transmission map",
15. Multimedia Tools and Applications, 79, 2020, doi:10.1007/s11042-020-08701-3. https://doi.org/10.1007/s11042-020-08701-3
16. R.Liu, X.Fan, M.Zhu, M.Hou, and Z.Luo, "Real-world underwater enhancement: Challenges, benchmarks, and solutions under natural light", IEEE Transacion. Circuits System, Video Technology, Vol. 30, No. 12, pp. 4861–4875, doi: 10.1109/TCSVT.2019.2963772, 2020.
17. O.G.Powar, "A review: Underwater image enhancement using dark channel prior with gamma correction", International Journal for Research in Applied. Science and Engineering Technology, Vol. 5, No. 3, pp. 421–426, 2017. https://doi.org/10.22214/ijraset.2017.3077
18. H.M.Abrams, "Lamination of composite eyeglass lenses", United States Patent 5433810,1995.
19. H.K Raut, V.A Ganesh, A.S Nair, and S.Ramakrishna, "Anti-reflective coatings: A critical, in-depth review", Energy and Environmental Science, Issue 10, 2011. https://doi.org/10.1039/c1ee01297e
20. A.Hore, and D.Ziou, "Image quality metrics: PSNR vs. SSIM", in Proc. 20th International Conference on Pattern Recognition, Istanbul, Turkey, pp. 2366_2369, 2010. https://doi.org/10.1109/ICPR.2010.579
21. Z.Wang, E.P. Simoncelli, and A.C.Bovik, "Multiscale structural similarity for image quality assessment", in Proc. 37th Asilomar Conference on Signals, Systems Computers, Vol 2, pp. 1398_1402, 2003.
22. Grosse. R, Johnson. M.K, Adelson E.H, and Freeman. W.T, "Ground truth dataset and baseline evaluations for intrinsic image algorithms", In Proceedings of IEEE 12th International Conference on Computer Vision, Kyoto, Japan, pp. 2335–2342, 2009. https://doi.org/10.1109/ICCV.2009.5459428
23. Kumari, J., Patidar, K., Saxena, Mr. G., & Kushwaha, Mr. R. (2021). A Hybrid Enhanced Real-Time Face Recognition Model using Machine Learning Method with Dimension Reduction. In Indian Journal of Artificial Intelligence and Neural Networking (Vol. 1, Issue 3, pp. 12–16). https://doi.org/10.54105/ijainn.b1027.061321
24. Anjaneyulu, P., Prasad, S. V. S., Syambabu, V., & Kumar, A. V. (2019). Deep Neural Network for Better Face Processing. In International Journal of Recent Technology and Engineering (IJRTE) (Vol. 8, Issue 4, pp. 2236–2239). https://doi.org/10.35940/ijrte.c6238.118419
25. Kumar S, P., & Balachander, Ms. B. (2019). Fast and Cost Efficient Face Detection System with CNN Using Raspberry PI. In International Journal of Engineering and Advanced Technology (Vol. 8, Issue 6, pp. 3037–3039). https://doi.org/10.35940/ijeat.f9034.088619
26. Prabhu, V., Thomas, D. R., & Kumar, V. S. (2019). Smart Glass for Visual Impaired People. In International Journal of Innovative Technology and Exploring Engineering (Vol. 8, Issue 12, pp. 3411–3415). https://doi.org/10.35940/ijitee.l2581.1081219
27. N, G., & K. R, Dr. R. (2022). Novel NOC Architecture for Designing and Implementing a Low Power Router using FPGA. In Indian Journal of Data Communication and Networking (Vol. 2, Issue 6, pp. 8–13). https://doi.org/10.54105/ijdcn.f5026.102622

AUTHORS PROFILE

Divya A.K. is currently an Associate Professor in the Department of Computer Science and Engineering at KVG College of Engineering, Sullia. She earned her B.E. degree in Electronics and Communication Engineering from Visvesvaraya Technological University (VTU) in 2003, and M.Tech. degree in Computer Network Engineering from VTU, Belagavi in 2012. Presently, she is pursuing her Ph.D. in Video Processing under the guidance of Dr. Bhaya H.K. and Dr. Ujwal U.J. at VTU, Belagavi. A member of the Indian Society for Technical Education (MISTE), Divya A. K. has published five international journal articles, presented at two international conferences, and participated in 15 faculty development programs. She has also demonstrated her commitment to education by teaching 20 undergraduate and postgraduate courses and has been recognized with NPTEL online certification courses. Her areas of interest include digital circuits, embedded systems, machine learning, image processing, and computer networks.

Dr. Bhagya H.K. is a professor in the Department of Electronics and Communication Engineering at KVG College of Engineering, Sullia. She earned her M.Sc. in Electronics from Mysore University in 1998 and her M.Tech. in Computer Cognition and Technology from Mysore University in 2008. She completed her Ph.D. from VTU, Belagavi, specializing in 3D Video Processing. Dr. Bhagya H.K. is a member of the Indian Society for Technical Education (MISTE) and serves on the Local Inspection Committee (LIC) of VTU. She has published 15 international journal articles, presented at 15 international conferences, and participated in 20 faculty development programs. Her academic contributions include teaching 25 undergraduate and postgraduate courses, and she has been recognized with NPTEL online certification courses. Additionally, she is a reviewer for AICTE-sponsored IEEE International Conferences. Her areas of interest include image and video processing, multimedia communication networks, digital signal processing, analog and digital communication systems, antenna theory and design, and advances in digital image processing.

Dr. Ujwal U.J. is a Professor and the Head of the Department of Computer Science and Engineering at KVG College of Engineering, Sullia. He earned his M.Tech. degree in System Analysis and Computer Applications from NITK, Surathkal in 2009 and completed his Ph.D. in Data Mining from VTU, Belagavi. He also serves as an executive council member at VTU, Belagavi, and has chaired numerous committees. With over 25 years of experience in cloud computing, Dr. Ujwal. U.J. has made significant contributions to both research and education.

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He is a member of MISTE, CSI, IEEE, and LIC. His achievements include publishing 25 international journal articles, presenting at 20 international conferences, and participating in 20 faculty development programs. Additionally, he holds two patents in biomedical engineering and electronics. In 2005, Dr.Ujwal.U.J. was nominated as a National Software Expert in the Global Information Technology division. His dedication to academia and passion for data mining, web mining, and cloud computing is evident through his extensive work and numerous accolades.