A BIOLOGICAL VISION INSPIRED FRAMEWORK FOR IMAGE ENHANCEMENT

M. A. Heena [1] and A.Vijaya Kumar [2]

[1]*Dept of Computer Science and Applications, School of Arts and Science, Vinayaka Mission's Research Foundation, Chennai, India.*

E-mail: heenaasina55@gmail.com

[2]*Asst. Professor Grade-II, Dept of Computer Science and Applications, School of Arts and Science, Vinayaka Mission's Research Foundation, Chennai, India.*

Email: vijayakumar.mca@avit.ac.in

Abstract— **Image enhancement is an important pre-processing step for many computer vision applications especially regarding the scenes in poor visibility conditions. In this work, we develop a unified two-pathway model inspired by the biological vision, especially the early visual mechanisms, which contributes to image enhancement tasks including low dynamic range (LDR) image enhancement and high dynamic range (HDR) image tone mapping. Firstly, the input image is separated and sent into two visual pathways: structure-pathway and detail-pathway, corresponding to the M- and P-pathway in the early visual system, which codes the low- and high-frequency visual information, respectively. In the structure-pathway, an extended biological normalization model is used to integrate the global and local luminance adaptation, which can handle the visual scenes with varying illuminations. On the other hand, the detail enhancement and local noise suppression are achieved in the detail-pathway based on local energy weighting. Finally, the outputs of structure and detail-pathway are integrated to achieve the low-light image enhancement. We present some recent models in biological vision and highlight a few models that we think are promising for future investigations in computer vision. To this extent, this paper provides new insights and a starting point for investigators interested in the design of biology-based computer vision algorithms and pave a way for much needed interaction between the two communities leading to the development of synergistic models of artificial and biological vision**.

Keywords— Night time image, low-light image, HDR image, visual adaptation, noise suppression

I. INTRODUCTION

Image enhancement is an important pre-processing step for many computer vision applications. In particular, the images captured under low-light or night-time conditions usually suffer the poor visibility and weak contrast. One interesting issue is how the human visual system (HVS) can efficiently resist various visual disturbances in complex visual scenes and maintain highly robust visual processing. It has been widely accepted in the field of visual neuroscience that visual adaptation mechanisms play a pivotal role in the phase of early visual

processing. In addition, from the viewpoint of engineering, benefited from the rapid advance of machine learning technologies (e.g., deep learning), researchers have made great progress in many applications in the computer vision area. However, these well-trained models are usually inefficient when processing low-light or night-time scenes because of the existing of various disturbances like noises.

Advances in our understanding of natural image statistics and of gain control within the retinal circuitry are leading to new insights into the classic problem of retinal light adaptation. Here we review what we know about how rapid adaptation occurs during active exploration of the visual scene. Adaptation mechanisms must balance the competing demands of adapting quickly, locally, and reliably, and this balance must be maintained as lighting conditions change. Multiple adaptation mechanisms in different locations within the retina act in concert to accomplish this task, with lighting conditions dictating which mechanisms dominate.

This paper presents an effective night-time vehicle detection system that combines a novel bio inspired image enhancement approach with a weighted feature fusion technique. Inspired by the retinal mechanism in natural visual processing, we develop a night-time image enhancement method by modelling the adaptive feedback from horizontal cells and the centre-surround antagonistic receptive fields of bipolar cells. Furthermore, we extract features based on the convolutional neural network, histogram of oriented gradient, and local binary pattern to train the classifiers with support vector machine. These features are fused by combining the score vectors of each feature with the learnt weights. During detection, we generate accurate regions of interest by combining vehicle taillight detection with object proposals. Experimental results demonstrate that the proposed bio-inspired image enhancement method contributes well to vehicle detection. Our vehicle detection method demonstrates a 95.95% detection rate at 0.0575 false positives per image and outperforms some state-of-the-art techniques. Our proposed method can deal with various scenes including vehicles of different types and sizes and those with occlusions and in blurred zones. It can also detect vehicles at various locations and multiple vehicles.

Adaptive Histogram Equalization (AHE) is a contrast enhancement method designed to be broadly applicable and having demonstrated effectiveness. However, slow speed and the over enhancement of noise it produces in relatively homogeneous regions are two problems. We report algorithms designed to overcome these and other concerns. These algorithms include interpolated AHE, to speed up the method on general purpose computers; a version of interpolated AHE designed to run in a few seconds on feedback processors; a version of full AHE designed to run in under one second on custom VLSI hardware; weighted , designed to improve the quality of the result by emphasizing pixels' contribution to the histogram in relation to their nearness to the result pixel; and clipped AHE, designed to overcome the problem of over enhancement of noise contrast.

The information of base layer will be transferred in the structure-pathway, and hence, adjusting luminance in the structure-pathway will not amplify the noises existing in the detail-pathway. On the other hand, the detail layer separated from the luminance will facilitate the noise suppression in the detail-pathway, as described below. Note that from the viewpoint of image processing, decomposing an image into various scales is a general technology, even in the image enhancement fields. For example, structure-texture decomposition has been widely used in image processing. However, in this work we revisited the structure-texture decomposition from the viewpoint of biological visual system. In addition, we employed the global noise estimation for parameter setting, which helps achieve adaptive decomposition for the scenes under different noise levels.

This objective function includes two terms: the first one is the difference term adapted to the texture component, which serves to preserve the meaningful structure. Therefore, together with the subjective evaluation and the objective metric, the proposed method obtains comparable performance with the recent state of-the-art methods. These are the advantages of this proposed work.

II. RELATED WORK

Pizer, Amburn, Austin, Cromartie, Geselowitz, Greer, ter Haar Romeny, Zimmerman, and Zuiderveld [4], in this research paper focuses on Adaptive histogram equalization (AHE) is a contrast enhancement method designed to be broadly applicable and having demonstrated effectiveness. However, slow speed and the over enhancement of noise it produces in relatively homogeneous regions are two problems. This reported algorithms designed to overcome these and other concerns. These algorithms include interpolated AHE, to speed up the method on general purpose computers; a version of interpolated AHE designed to run in a few seconds on feedback processors; a version of full AHE designed to run in under one second on custom VLSI hardware; weighted AHE, designed to improve the quality of the result by emphasizing pixels' contribution to the histogram in relation to their nearness to the result pixel; and clipped AHE, designed to overcome the problem of over enhancement of noise contrast. This paper concludes that clipped AHE should become a method of choice in medical imaging and probably also in other areas of digital imaging, and that clipped AHE can be made adequately fast to be routinely applied in the normal display sequence.

Kim [5], in this research paper given a Contrast enhancement is an important factor in the grey scale images. One of the widely accepted contrast enhancement method is the Histogram equalization (HE). HE achieves comparatively better performance on almost all types of image but sometimes produces excessive visual deterioration. The proposed Contrast Enhancement using Brightness Preserving Histogram Plateau Limit (CEBPHPL) method provides better brightness preservation without allowing in excess of contrast improvement measure. This method decomposes the input image by computing the local maxima of the smoothed image using Gaussian filter which reduces the noise. Then the clipping process has been implemented which provides the good enhancement rate than the conventional methods. The experimental result of the proposed CEBPHPL is better than the existing methods.

Jobson, Rahman, and Woodall [10], in the work stated that the recognition have sought to define a practical implementation of the retina without particular concern for its validity as a model for human lightness and colour perception. We describe the trade-off between rendition and dynamic range compression that is governed by the surround space constant. Further, unlike previous results, we find that the placement of the logarithmic function is important and produces best results when placed after the surround formation. Also unlike previous results, we find the best rendition for a "canonical" gain/offset applied after the retina operation. Various functional forms for the retina surround are evaluated, and a Gaussian form is found to perform better than the inverse square suggested by Land. Images that violate the grey world assumptions (implicit to this retinex) are investigated to provide insight into cases where this retina fails to produce a good rendition.

Land and McCann [9], in this theory assumes that there are three independent cone systems, each starting with a set of receptors peaking, respectively, in the long-, middle-, and short-wavelength regions of the visible spectrum. Each system forms a separate image of the world in terms of lightness that shows a strong correlation with reflectance within its particular band of wavelengths. These images are not mixed, but rather are compared to generate color sensations. The problem then becomes how the lightness of areas in these separate images can be independent of flux. This article describes the mathematics of a lightness scheme that generates lightness numbers, the biologic correlate of reflectance, independent of the flux from objects

Chulwoo Lee, Chul Lee, Chang-Su Kim [8], in this novel contrast enhancement algorithm based on the layered difference representation of 2D histograms is proposed in this paper. We attempt to enhance image contrast by amplifying the gray-level differences between adjacent pixels. To this end, we obtain the 2D histogram $h(k, k + 1)$ from an input image, which counts the pairs of adjacent pixels with gray-levels k and $k + 1$, and represent the gray-level differences in a tree-like layered structure. Then, we formulate a constrained optimization problem based on the observation that the gray-level differences, occurring more frequently in the input image, should be more emphasized in the output image. We first solve the optimization problem to derive the transformation function at each layer. We then combine the transformation functions at all layers into the unified transformation function, which is used to map input gray-levels to output gray-levels. Experimental results demonstrate that the proposed algorithm enhances images efficiently in terms of both objective quality and subjective quality.

III. PROCESS AND METHODOLOGY

A. Human visual system:

Image enhancement is an important pre-processing step for many computer vision applications. In particular, the images captured under low-light or night time conditions usually suffer the poor visibility and weak contrast. One interesting issue is how the human visual system (HVS) can efficiently resist various visual disturbances in complex visual scenes and maintain highly robust visual processing. It has been widely accepted in the field of visual neuroscience that visual adaptation mechanisms play a pivotal role in the phase of early visual processing. In addition, from the viewpoint of engineering, benefited from the rapid advance of machine learning technologies (e.g., deep learning), researchers have made great progress in many applications in the computer vision area. However, these well-trained models are usually inefficient when processing low-light or night time scenes because of the existing of various disturbances like noises.

B. Adaptive histogram equalization:

Most of the classical image enhancement methods focus on adjusting the histogram of input images to manifest more visual details. For example, histogram equalization (HE) and its variations (e.g., adaptive histogram equalization (AHE), bi-histogram equalization (BHE), contrast limited adaptive histogram equalization (CLAHE) aim to adjust the distribution of histogram by imposing different regularization terms. In addition, contextual and variational contrast enhancement methods employ contextual information to perform nonlinear data mapping for visual enhancement. As a representative one, a contrast enhancement method based on the layered difference representation of two-dimensional (2D) histogram was also proposed.

C. Simultaneous reflectance and illumination estimation:

On the other hand, inspired by the biological mechanisms involved in the early visual system, the famous Retinex theory assumes that a visual image can be decomposed into two components, reflectance and illumination. I have developed multiple versions based on the Retinex theory for image enhancement, single-scale Retinex (SSR), multi-scale Retinex (MSR) etc. proposed a method to preserve the naturalness of non-uniform illumination images by mapping the illumination with a bi-log transformation to make a balance between the details and naturalness. Recently, a weighted variational model for simultaneous reflectance and illumination estimation (SRIE) can preserve more details while suppressing the noises to some extent. Park et al. proposed a low-light image enhancement method using variational optimization-based Retinex model and proposed a low-light image enhancement method with robust Retinex model by additionally considering a noise map. Along with this line, the method proposed by can achieve high performance and efficiency on low-light image enhancement with a well-constructed illumination map.

D. Pathway Separation with Global Noise Estimation:

Low-light images, especially night time images, usually suffer from serious noises. In order to improve the visual quality of such images, the noises must be suppressed or removed during the processing of image enhancement. Generally, directly improving the light of scenes also amplifies the noises, which will increase the difficulty of noise suppression or removing. With the separated visual pathways, the luminance can be adjusted (enhanced) in the structure-pathway and the noise suppression is achieved in the detail-pathway. Biologically, found that some LGN cells in cats respond quite weakly to the stimulus of dispersedly distributed dots, in Comparison to that of the compactly distributed dots (e.g., the dispersedly distributed dots are compacted into a line). This physiological finding suggests that some LGN cells (usually for high-frequency information processing) could be used for noise suppressing with detail preserving. From the point of view of engineering, denoising can be achieved based on the image decomposing methods.

IV. RESULTS

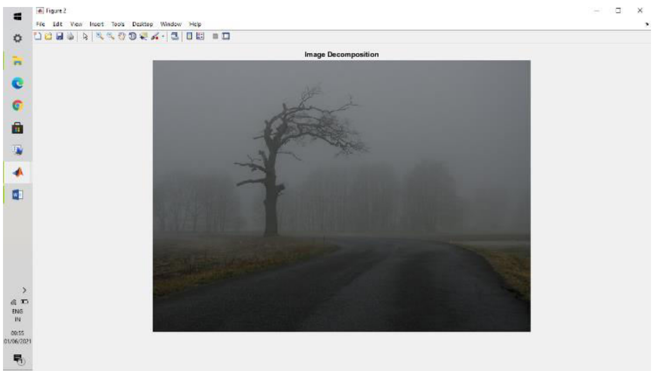

Fig. 1: Image Decomposition

In this fig. 1. Shows Image Decomposition by the background of the image is made dark by adjusting the saturation of the image so that the tree is this image is clearly visible by making a dull background.

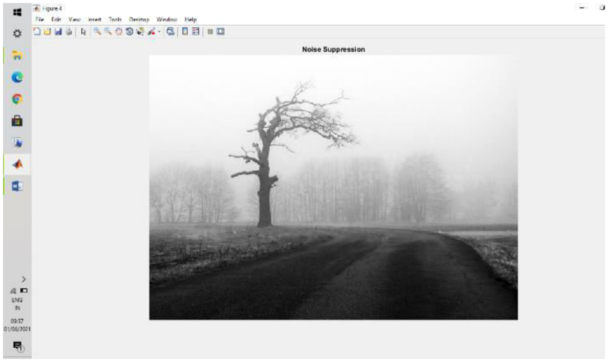

Fig. 2: Noise Suppression

In this fig. 2,The noise in the image is cleared by smoothening the image this makes the tree to look darker and background is fog filled.

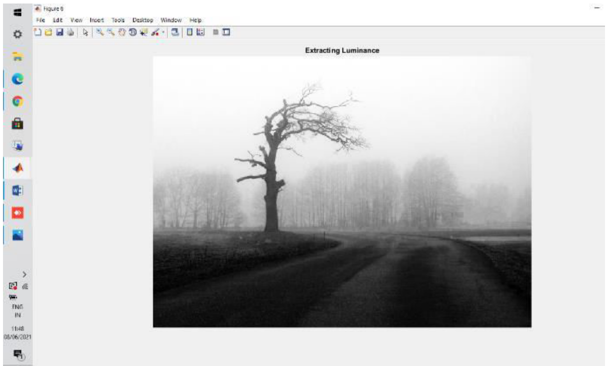

Fig. 3: Extracting Luminance

In the Fig. 3, the luminance of the image is adjusted by making the background as faded so that that tree in the image is clearly visible

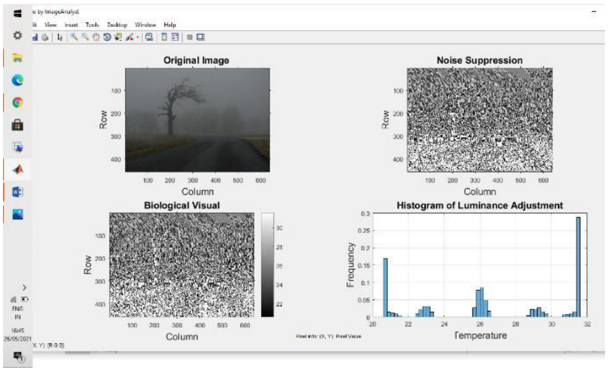

Fig. 4: Demo by Image Analyst

Fig.4, this image is analysis noise suppression luminance adjustment and biological visual is shown by the graph by comparing it to the original image.

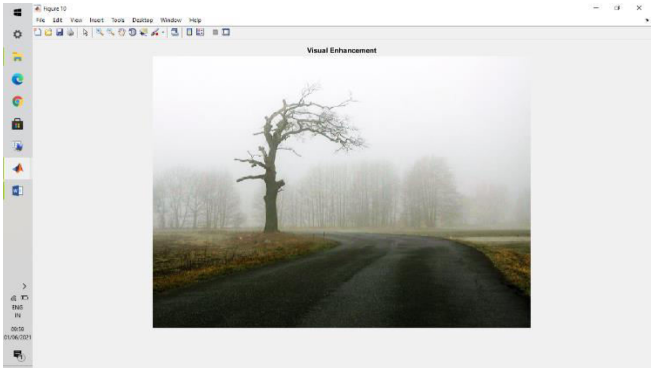

Fig. 5: Visual Enhancement

In this fig.5, the pixel quality is adjusted to high level range so that the resolution of the image is increased to image brightness, saturation , and sharpness are adjusted to perfect level to enhance the quality of the image.

V. CONCLUSION

In this paper, proposes a biological visual mechanisms inspired image enhancement framework. In particular, the two pathway processing can efficiently disassemble the wrapped problems of low-quality images into multiple specific tasks, including luminance brightening, detail enhancing, noise suppressing, etc. In addition, the system systemically employed a global to-local strategy for luminance adaptation, contrast enhancement and noise estimation. Extensive experiments on different datasets show that the proposed method can be directly used for night-time and low-light image enhancement and simply extended for HDR image tone mapping, and provide quite comparable performance in comparison to the recent state-of the- art methods, but in a quite faster way. Note that as an image enhancement method in poor visibility conditions, the proposed method focuses on improving the visibility of the details especially in dark or low light regions.

REFERENCE

[1] F. Rieke and M. E. Rudd, "The challenges natural images pose for visual adaptation," Neuron, vol. 64, no. 5, pp. 605–616, 2009.

[2] Y. LeCun, Y. Bengio, and G. Hinton, "Deep learning," nature, vol. 521, no. 7553, p. 436, 2015.

[3] H. Kuang, X. Zhang, Y.-J. Li, L. L. H. Chan, and H. Yan, "Night time vehicle detection based on bio-inspired image enhancement and weighted score-level feature fusion," IEEE Trans. Intelligent Transportation Systems, vol. 18, no. 4, pp. 927–936, 2017.

[4] S. M. Pizer, E. P. Amburn, J. D. Austin, R. Cromartie, A. Geselowitz, T. Greer, B. ter Haar Romeny, J. B. Zimmerman, and K. Zuiderveld, "Adaptive histogram equalization and its variations," Computer Vision, Graphics, and Image Processing, vol. 39, no. 3, pp. 355–368, 1987.

[5] Y.-T. Kim, "Contrast enhancement using brightness preserving bihistogram equalization," IEEE Trans. Consumer Electronics, vol. 43, no. 1, pp. 1–8, 1997.

[6] E. D. Pisano, S. Zong, B. M. Hemminger, M. DeLuca, R. E. Johnston, K. Muller, M. P. Braeuning, and S. M. Pizer, "Contrast limited adaptive histogram equalization image processing to improve the detection of simulated spiculations in dense mammograms," Journal of Digital Imaging, vol. 11, no. 4, pp. 193–200, 1998.

[7] T. Celik and T. Tjahjadi, "Contextual and variation contrast enhancement," IEEE Trans. Image Processing, vol. 20, no. 12, pp. 3431–3441, 2011.

[8] C. Lee, C. Lee, and C.-S. Kim, "Contrast enhancement based on layered difference representation of 2D histograms," IEEE Trans. Image Processing, vol. 22, no. 12, pp. 5372–5384, 2013.

[9] E. H. Land and J. J. McCann, "Lightness and retinex theory," Journal of the Optical Society of America A: Optics, Image Science & Vision, vol. 61, no. 1, pp. 1–11, 1971.

[10] D. J. Jobson, Z.-u. Rahman, and G. A. Woodell, "Properties and performance of a center/surround retinex," IEEE Trans. Image Processing, vol. 6, no. 3, pp. 451–462, 1997