A Simulation of Night Vision Technology Aided with AI

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Abstract -- **A new method of natural color mapping is proposed, that matches rendered imagery output of the target image with a huge reference image database. The methods which are already in use, end up with false color. It results in unnatural vision in case 'global' color statistics of target image are too different from that of actual night-vision scene. In present day scenario US-Military uses the most advance night vision system which combines image enhancement, visible imagery and thermal imagery. The fusion data is then processed with deep convolution network, via 'Image Super Resolution'. The subjects, in the vision (*i.e.* background, foreground and objects) are then identified using YOLO algorithm, which help AI to identify and match the color based on the reference image database. Since the system AI incorporate huge database learning, the predicted color scheme for the targeted scene in the night vision imagery is matched with high probability. There are many methods for color mapping available, but histogram matching is used in this research paper.**

Keywords: Night vision technology, False-color rendering, Color mapping, Diffusion filtering, Multi-resolution

I. INTRODUCTION

EXPERIMENTS show that suitable false-color rendering of night-time imagery significantly improves observer performance alongwith reaction times where scene segmentation and classification are involved. Human performance gets affected due to inappropriate color mappings. The reasons often cited for inconsistent or inappropriate color mapping is lack of constancy in physical color. A color rendering method that renders night vision imagery with a 'naturalistic', feeling is ideal [1].

The vision data which we receive from sensors are then processed using latest imagery data fusion technology employed by US-Military for their night vision systems. GSCI fusion system superimposes the visionary data from both sensors and produces night vision with some colors that distinguish mostly warm and cold bodies [2, 3]. Thermal sensor works on the phenomena of black body radiation. When there is no warm body or in the absence of black body radiation and it's pitch dark, then a method of active illumination is used to overcome the problem of insufficient data. This raw imagery data is then fused to lighten-up with all the available color and textures. These details help the object detection algorithm to work effectively. Once the imagery is identified, against the reference database, using deep neural operation, it is easy to map colors to the visionary.

II. RELATED WORK

Reinhard *et al.* [4] introduced a method to transfer one image's color characteristics to another for addressing the problem of unnatural color mapping. It was designed to impart natural appearance to synthetic images. It uses a transformation to a principal-component space derived from a reasonably large ensemble of hyper-spectral images of natural scenes. Simone *et al*. showed that in such a de-correlated color space, the first-order statistics of natural color images *i.e.* target scenes are transferred to the multiband night-vision images *i.e.* source scenes [5]. Important requirement is that the source and target scenes have similar chromatic properties. According to Toet *et al.,* Reinhard's method can be adapted to implement the natural color characteristics of daylight color imagery into multiband fused night-vision images. This natural color mapping method matches the statistical properties such as mean and standard deviation of night-vision imagery to that of a natural daylight color image. It colors the image regardless of scene content, and therefore coloring accuracy is dependent on how well the target and source images are matched [6]. Specifically, target image weights local regions of the source image by the global color statistics of the target image. Accordingly, it will yield less naturalistic results in case target and source image are not matched with respect to structural content. Based on this framework, namely 'global coloring', a new 'local coloring' method is proposed to addresses the above problem to produce colored NV images that appear more like realistic daylight imagery.

III. LIMITATION OF EXISTING METHOD

The problem with today's night vision technology is that, it is not able to match color near to daylight of the targeted scene. The process which is used right now is to superimpose the two imagery data, one from the visible region (some color and texture data), and another from the infrared region (monochrome) with predicted color mapping use a reference image.

How can the night vision system predict and map day light color to the live to the target scene, such that it can be more informative and helpful in judging the environment especially useful for military purposes?

IV. PROPOSED SYSTEM MODEL

The model is designed keeping in mind the practical realisation of the system in today's available technology and resources (Fig.1).

The system is based on the latest night vision system that uses two sensor systems. The IR sensor (VNIR), which captures the low light visible image data in near infrared range, captures the available colors and the texture information in the vision [7, 8]. Other sensor is the thermal imaging wide infrared range sensor, which is supported by Active illumination tech., captures the details available in monochrome. This information is fused using the latest technology, GSCI Fusion mode. Followed by the image super resolution technology which refines the imagery with the help of neural processing unit. The high definition data is now available which can be used for object detection. YOLO, (you only look once) is the algorithm which is employed with Google dataset to identify, background, foreground and objects. Now comes the most important part which is identifying the suitable local reference image for mapping its color to target vision. For matching of color, the local coloring method with support of histogram matching has been introduced [9].

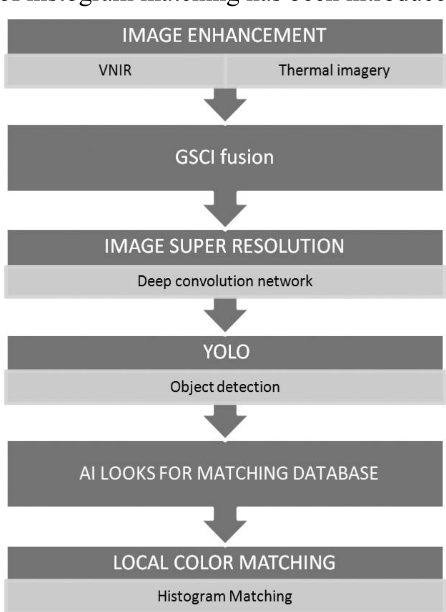

Figure 1. Proposed model for image enhancement.

V. IMPROVED METHOD

This paper discusses a new method that yields the colored NV images appear more like daylight imagery. Major points to achieve improvements are: (*a*) The source image is rendered segment-by-segment based on identified features – specifically, the false color image is region-segmented by its feature properties. A nonlinear diffusion filtering process is employed to the false-colored image for reducing the number of colors [14]. Based on histogram analysis, a set of preliminary clusters are formed via anisotropically dividing three components of the diffused image in lαβ space. These clusters are then merged to produce final segments provided their centric distances (corresponding to the diffused image) in 3D lαβ color space are less than a given threshold. (*b*) Histogram-matching replaces statistical matching to ensure the source image more closely resembles the target image with respect to chromaticity [10]. (*c*) Averaged mean, standard deviation and histogram of a large sample of natural scene images instead of a single color image, are used as the target color properties for each color scheme. Target color schemes are grouped by their contents namely green plants, mountain, roads, sky, ground/earth, water, buildings, people, etc. [11]. (*d*) Training and classifying process leads to mapping between the source region segments and target color schemes. Algorithm called YOLO takes care of the pattern and object recognition [16, 18].

There can be many application of this technology, for example:

Smart Night vision system: This technology can give an edge to the soldiers in the worst case scenario where the Indian Army can easily outperform on the battlefield, as this system can improve the night visionary revolutionarily. The object detection tech can be taught to recognise enemy and the weapons they carry. The system then can alert the soldier to prepare accordingly [15].

Driverless cars: This system will help the driverless car intelligence to learn their environment better at night. They can distinguish various sign boards and the traffic lights as the visionary will have colors which give the car AI to understand different signboards at night.

Aircraft landing/ take-off: The landing and take-off of the planes and helicopters can be perfected using the color night visionary. The autopilot mode of flying can be improved incredibly.

Wildlife safari and Deep sea diving: The wildlife in the national parks will be more alive and clear at night with the help of this system. Similarly, the deep sea exploration will be easier, as the system can see colors in the deep dark sea.

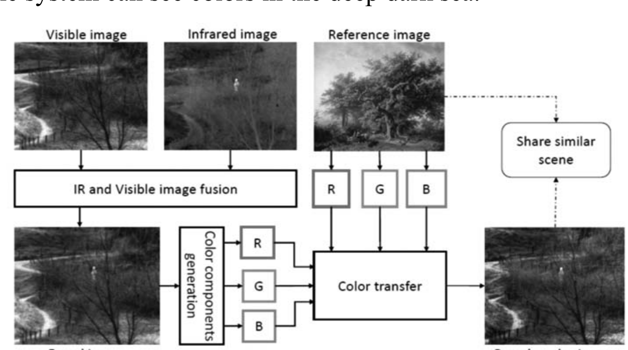

Figure 2. Actual image enhancement steps.

Figure 3. Different Images.

VI. ANALYSIS AND SIMULATION

Since image contents vary dramatically from image to image, image segmentation is quite challenging. Using combination of diffusion, clustering and region merging techniques make the process quite flexible. A reasonable segmentation is obtained by giving a set of proper parameter values, or even by redefining the distance between clusters. Another issue is to recognize different segments in NV images [17]. But it is found, it is feasible to distinguish some limited background objects. Interestingly, histogram-matching method gives a more saturated color image than via statistical-matching. However, the histogram-matching procedure can cause various 'over-shoot' problems (such as over saturated colors) especially for a small image segment. So, while matching small segments (*e.g.,* identified by the area) in a false-colored NV image, one could increase matching region by merging similar segments together or use the statistical-matching only [12, 13].

VII. CONCLUSION

This paper considered the problem of perceptual performance perceived by relatively impoverished information conveyed in night time natural scenes. Used images of night time outdoor scenes rendered in image-intensified low-light visible sensors, thermal infrared (IR) sensors, and GSCI fusion technique with information added.

REFERENCES

[1] A. Toet, "Natural color mapping for multiband night vision imagery", *Information Fusion*, vol.4, pp.155-166, 2003.

[2] G. Piella, "A general framework for multi-resolution image fusion: from pixels to regions", *Ibid.,* vol.4, no.4, pp.259-280, 2003.

[3] R. Singh, M. Vatsa and A. Noore, "Integrated multilevel image fusion and match score fusion of visible and infrared face images for robust face recognition", *Pattern Recognition*, vol.41, no.3, pp.880-893, 2008.

[4] E. Reinhard, M. Adhikhmin, B. Gooch and P. Shirley, "Color transfer between images", *IEEE Computer Graphics and Applications*, vol.21, no.5, pp.34–41, Sep. 2001.

[5] G. Simone, A. Farina, F. C. Morabito, S. B. Serpico and L. Bruzzone, "Image fusion techniques for remote sensing applications", *Information Fusion*, vol.3, no.1, pp.3-15, 2002.

[6] S. Li, B. Yang and J. Hu, "Performance comparison of different multi-resolution transforms for image fusion", *Ibid.*, vol.12, no.2, pp.74–84, 2011.

[7] E.A. Essock, M.J. Sinai, J.S. McCarley, W.K. Krebs and J.K. DeFord, "Perceptual ability with real-world nighttime scenes: imageintensified, infrared, and fused-color imagery", *Human Factors*, vol.41, no.3, pp.438-452, 1999.

[8] A. Toet and J.K. IJspeert, "Perceptual evaluation of different image fusion schemes", in: I. Kadar (Ed.), *Signal Processing, Sensor Fusion, and Target Recognition X*, The International Society for Optical Engineering, Bellingham, WA, 2001, pp. 436-441.

[9] J.T. Varga, "Evaluation of operator performance using true color and artificial color in natural scene perception (Report ADA363036)", Naval Postgraduate School, Monterey, CA, 1999.

[10] W.K. Krebs, D.A. Scribner, G.M. Miller, J.S. Ogawa and J. Schuler, "Beyond third generation: a sensor-fusion targeting FLIR pod for the F/A-18", in: B.V. Dasarathy (Ed.), *Sensor Fusion: Architectures, Algorithms, and Applications II*, International Society for Optical Engineering, Bellingham, WA, USA, 1998, pp.129-140.

[11] M.D. Fairchild, *Color Appearance Models*, Addison Wesley Longman Inc., Reading, MA, 1998.

[12] M. Nielsen, P. Johansen, O.F. Olsen and J. Weickert, eds., *Scale-Space Theories in Computer Vision*, vol. 1682 of Lecture Notes in Computer Science, Springer, Berlin, 1999.

[13] O. Scherzer and J. Weickert, "Relations between regularization and diffusion filtering", *J. Mathematical Imaging and Vision*, vol.12, pp. 43-63, 2000.

[14] E.A. Essock, J.S. McCarley, M.J. Sinai and J.K. DeFord, "Human Perception of Sensor-Fused Imagery", *Interpreting Remote Sensing Imagery: Human Factors* (edited by Robert R. Hoffman, Arthur B. Markman), Lewis Publishers, Boca Raton, Florida, February 2001.

[15] H.C. Burger, C.J. Schuler and S. Harmeling, "Image denoising: Can plain neural networks compete with BM3D?" in: *Proc. IEEE Conference on Computer Vision and Pattern Recognition*, pp. 2392-2399, 2012.

[16] Z. Cui, H. Chang, S. Shan, B. Zhong and X. Chen, Deep network cascade for image super-resolution" in *Proc. European Conference on Computer Vision*, pp. 49-64, 2014.

[17] N. Damera-Venkata, T.D. Kite, W.S. Geisler, B.L. Evans and A.C. Bovik, "Image quality assessment based on a degradation model", *IEEE Trans. Image Processing,* vol. 9, no.4, pp.636-650, 2000.

[18] C. Dong, C.C. Loy, K. He and X. Tang, "Learning a deep convolutional network for image super resolution", *Proc. European Conference on Computer Vision*, pp. 184-199, 2014.

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