A Simulation of Night Vision Technology Aided with AI

Amit Tiwari[1] FIETE and **Jalaj Gupta**[2]
Development and Engineering, Microwave Components Division,
Bharat Electronics Limited, Ghaziabad 201010 UP India
[1]amittiwari@bel.co.in

Abstract— **A new method of natural color mapping has been proposed, which matches the rendered imagery output of the target image with a huge reference image database. The methods already in use, end up with false color. This makes the vision unnatural if the target image's "global" color statistics are too different from that of the night vision scene (*e.g.*, it would appear to have too much green if much more foliage was contained in the target image). 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, using technology called, 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, Image super resolution, YOLO algorithm, GSCI fusion system, Artificial intelligence

I. INTRODUCTION

EXPERIMENTS have shown that appropriately designed false-color rendering of night-time imagery can significantly improve observer performance and reaction times in tasks that involve scene segmentation and classification. Unfortunately, inappropriate color mappings have also been shown to be detrimental to human performance. One of the reasons often cited for inappropriate or inconsistent color mapping is lack of physical color constancy. Ideally, a color rendering method should render night vision imagery with a 'naturalistic', as well as be stable [1].

Vision data which we receive from the sensors are 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]. The 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.

The objective of the research is to make the night vision system a state-of-the-art system with advance coloring technology which will indeed be more helpful, in reading and predicting the environment in the night.

II. RELATED WORK

To address the problem of unnatural color mapping, Reinhard *et al*. recently introduced a method to transfer one image's color characteristics to another [4]. The method was designed to give synthetic images a natural appearance. The method employs a transformation to a principal component space that has recently been derived from a large ensemble of hyper spectral images of natural scenes. In this decorrelated color space, the first order statistics of natural color images (target scenes) are transferred to the multiband night-vision images (source scenes) [5]. The only requirement of that method is that the source and target scenes possess similar chromatic properties (*i.e*., scenes were selected manually). More recently, Toet reported that Reinhard's method could be adapted to implement the natural color characteristics of daylight color imagery into multiband fused night-vision images. Essentially, Toet's natural color mapping method matches the statistical properties (*i.e*., mean and standard deviation) of night-vision (NV) imagery to that of a natural daylight color image (manually selected as the "target" color distribution). However, that particular color mapping method colors the image regardless of scene content, and thus the accuracy of the coloring is very much dependent on to how well the target and source images are matched [6]. Specifically, the target image weights the local regions of the source image by the global color statistics of the target image, and thus will yield less naturalistic results if the target and source image are not matched with respect to structural content. Based on Toet's framework (referred to here as "global coloring"), in this paper a new "local coloring" method that addresses the above mentioned global color bias problem to produce colored NV images that appear more like realistic daylight imagery has been proposed.

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 live to the target scene, such that it can be more informative and helpful in judging the environment especially useful for military purposes?

III. PROPOSED SYSTEM MODEL

The model is designed keeping in mind the practical realisation of the system in today's available technology and resources as shown in 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]. The other sensor is the thermal imaging wide infrared range sensor, supported by Active illumination technique, 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 color, the local coloring method with the support of histogram matching has been introduced [9].

V. IMPROVED METHOD

This paper discusses a new local-coloring method that makes the colored NV images appear more like daylight imagery. The major points for this new method to achieve these improvements are: (*a*) The source image is rendered segment-by-segment based on identified features (*i.e.*, local-coloring) – specifically, the false color image is region-segmented by its feature properties (corresponding to its contents). A nonlinear diffusion filtering process is applied to the false-colored image to reduce the number of colors [14]. A set of preliminary clusters are then formed by anisotropically dividing the three components of the diffused image in lαβ space based on their histogram analysis. These clusters are then merged to produce final segments if their centric distances (corresponding to the

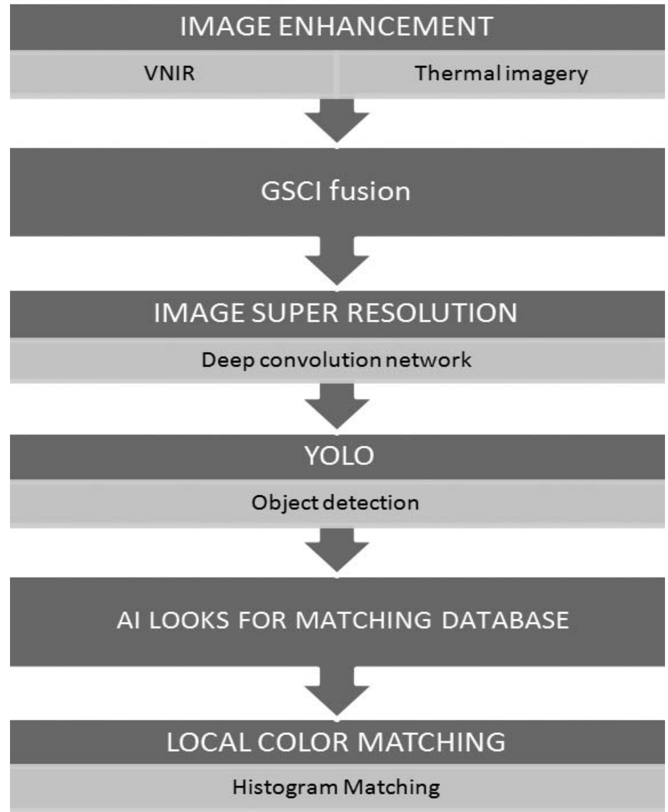

Figure 1. Proposed model for image enhancement.

diffused image) in 3D lαβ color space are less than a given threshold. (*b*) The statistical matching procedure is merged and replaced with the histogram-matching to assure that the source image more closely resembles the target image with respect to chromaticity [10]. (*c*) Instead of a single color image, the averaged mean, standard deviation and histogram of a large sample of natural scene images are used as the target color properties for each color scheme. Corresponding to the source region segments, the target color schemes are grouped by their contents (or colors) such as green plants, mountain, roads, sky, ground/earth, water, buildings, people, etc [11]. (*d*) The mapping between the source region segments and target color schemes can be done automatically by training and classifying process (*i.e.*, pattern recognition). This pattern recognition portion is taken care by the pattern and object recognition algorithm called YOLO (You only look once) [16,18].

There can be many applications 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 technology 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/takeoff: The landing and takeoff 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.

VI. ANALYSIS & SIMULATION

Image segmentation is quite challenging because image contents vary dramatically from image to image. However, the combination of diffusion, clustering and region merging techniques make the segmentation very flexible. For example, a reasonable segmentation can be obtained by giving a set of proper parameter values, or even by redefining the distance between clusters.

Another challenging task is to recognize difference segments contained in NV images [17]. However, it is feasible to automatically distinguish some limited or listed background objects. The histogram-matching method usually gives a more saturated color image than statistical-matching does. However, the histogram-matching procedure can cause various 'over-shoot' problems (such as over saturated colors) especially for a small image segment. Therefore, while matching small segments (*e.g.*, identified by its area) in a false-colored NV image, one can either increase the matching region by merging similar segments together (*i.e.*, by enlarging Td), or use the statistical-matching only [12, 13].

VII. CONCLUSION

Human perceptual performance allowed by relatively impoverished information conveyed in night time natural scenes was investigated. Used images of night time outdoor scenes rendered in image-intensified low-light visible sensors,

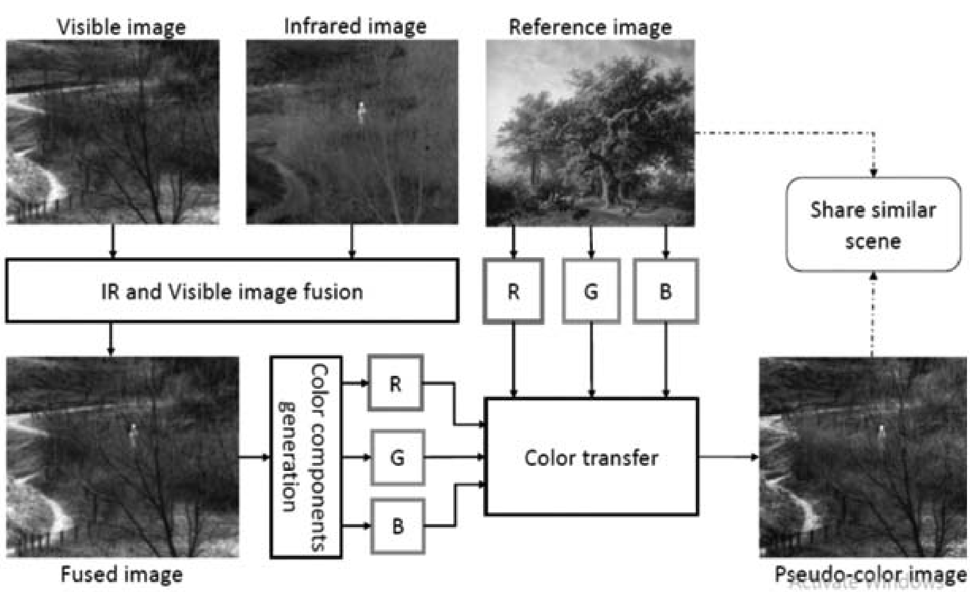

Figure 2. Actual image enhancement steps.

Figure 3. Different images.

thermal infrared (IR) sensors, and GSCI fusion technique with information added and found that night time imagery provides adequate low-level image information for effective perceptual organization on a classification task, but that performance within a given object category is dependent on the image type. Overall performance was best with the false-color fused images. This is consistent with the suggestion in the literature that color plays a predominate role in perceptual grouping and segmenting of objects in a scene and supports the suggestion that the addition of color in complex achromatic scenes aids the perceptual organization required for visual search and better understanding of the surrounding. Applications of this research include improving night vision to a smart night vision system which is capable of recognising scenes and object and reporting it to the user on the display module, increasing its field of use widely.

REFERENCES

[1] A. Toet, "Natural color mapping for multiband night vision imagery", *Information Fusion,* vol. 4, pp. 155-160, 2003.

[2] G. Piella, "A general framework for multi-resolution image fusion: from pixels to regions", *Information Fusion,* 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, 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", *Information Fusion,* 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: image intensified, infrared, and fused-color imagery", *Interpreting Remote Sensing Imagery: Human Factors,* vol. 41, no. 3, pp. 438–452, 1999.

[8] A. Toet and J.K. IJ speert, "Perceptual evaluation of different image fusion schemes", in: I. Kadar (Ed.), *Proc. 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.), *Proc. 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", *Journal of 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?" , *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", *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.

Amit Tiwari FIETE graduated in Engineering in Electronics and Communication and obtained Master of Technology degree in Microwave Engineering from IT-BHU. Served MITS and Institute of Engineering, Jiwaji University Gwalior as an assistant professor. Currently working as Manager, in Development and Engineering-Microwave Components of Bharat Electronics Limited, Ghaziabad. Designed and developed Airborne RF Transceivers for AEW&CS (DL), IFF Transmitters for Radars, SSPA, Receivers and its components etc for Data link and radar applications. Published around 20 research papers in international journals/ conferences. Was conferred the IETE Devi Singh Tyagi Memorial Award 2018.

Jalaj Gupta is pursuing BTech (Final) from Dr. A.P.J. Abdul Kalam Technical University (formerly UP Technical University). He has interest in recent communication technologies.