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Color remapping turns night into day

Alexander Toet

A real-time mapping technique enables full-color rendering of multi-spectral nighttime images, making them as clear and colorful as daylight ones.

Night vision cameras are a vital source of information for a wide range of critical military and law enforcement applications such as surveillance, reconnaissance, intelligence gathering, and security. Currently, monochrome display of night imagery is still the standard. However, monochrome images often do not look natural, provide lower feature contrast, and tend to induce visual illusions and fatigue. Intuitive color representations of night-vision imagery may alleviate these problems.

The increasing availability of multi-spectral, night-vision systems has led to a growing interest in the color display of night imagery. Color may improve feature contrast and reduce visual clutter, thus enabling better scene recognition, object detection, and depth perception. Most current techniques to colorize multi-band, night-time imagery are computationally expensive or do not yield natural and stable color settings. To resolve these issues, we developed a simple color remapping technique that provides colored night-time imagery with an intuitive and stable appearance.[1] The method is computationally efficient and can easily be deployed in real-time.

Our color remapping technique assumes a fixed relation between false color tuples and natural color triplets for bands near the visual spectrum. This allows its implementation as a simple color table swapping operation. For bands that are not correlated with the visual spectrum, color remapping can be used to enhance the detectability of targets through contrast enhancement and color highlighting.

We achieved color remapping by mapping the multi-band sensor signal to an indexed false color image and swapping its color table with that of a regular daylight color image of a similar scene (see Figure 1). A wide range of environments can be represented with only a limited number of color tables. These tables need to be constructed only once, before the system is deployed.

The derivation of the color transformation requires a color photograph representing the intended operating theater or a similar, but not necessarily the same, environment. Then there are two options: either transfer the color statistics of this photograph to the false color multi-spectral image (when both images represent different but similar scenes), or establish a sample-based mapping between corresponding pixel values.[1]

We achieved an efficient real-time implementation by using indexed color image representations and performing all required operations on their corresponding color lookup tables.

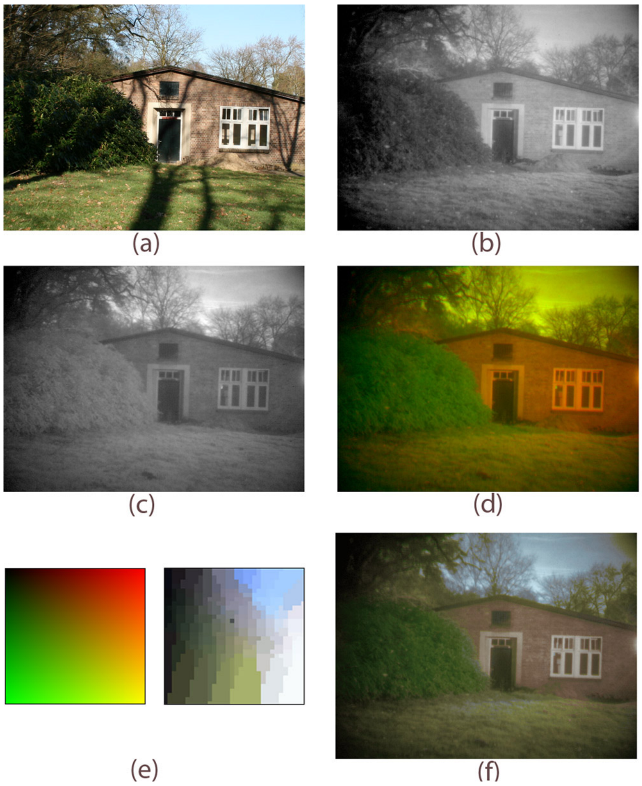

Figure 1. *(a) Daylight color image, (b) visible, and (c) near-IR night-time images of the same scene. (d) False color representation of (b) and (c). (e) Color tables of (d) and (a). (f) Image (d) after color remapping.*

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Although the sample-based mapping approach yields more specific colors than the statistical method, both techniques produce intuitively correct and stable color mappings (see Figure 2). The specificity of the sample-based color remapping also allows us to selectively enhance and emphasize certain details in a scene.

We implemented our color mapping procedure in three portable real-time, multi-band night-vision systems[2–4] that were deployed systems in several night-time field trials.[5,6] It appears that color makes it significantly easier to distinguish more details and grab the gist of a scene.[7] Mappings emphasizing hot targets

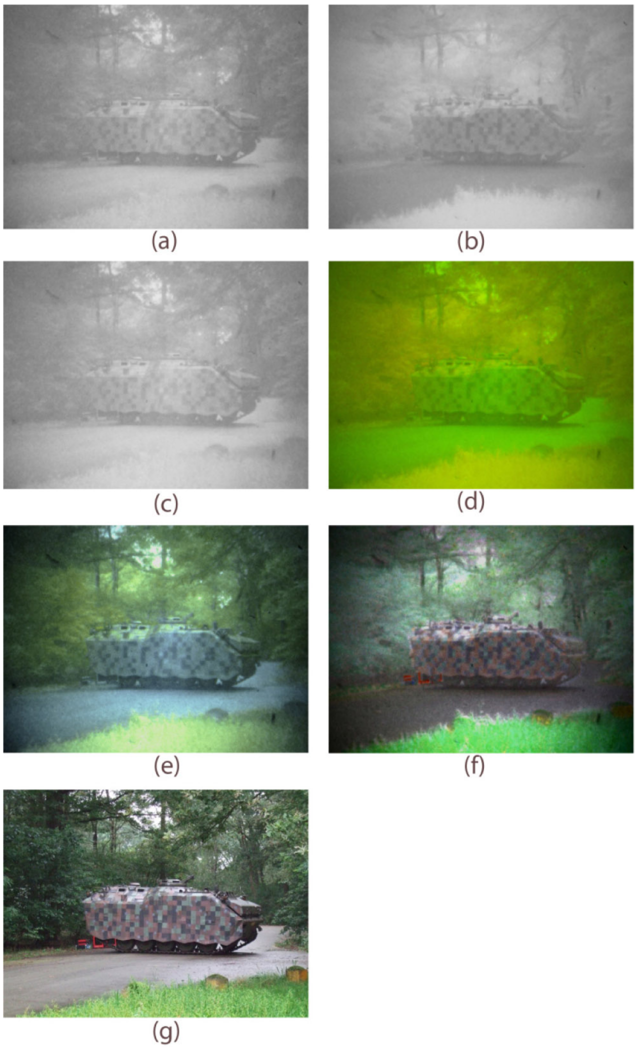

Figure 2. (a) Visual, (b) near IR, and (c) intensified image of the same scene. (d) False color image produced from (a) and (b). (e) Result of transferring the scene's color statistics to image (d). (f) Result of a sample-based color transform of image (d) using samples from the image pair (d) and (g). (g) Daylight color image of the scene.

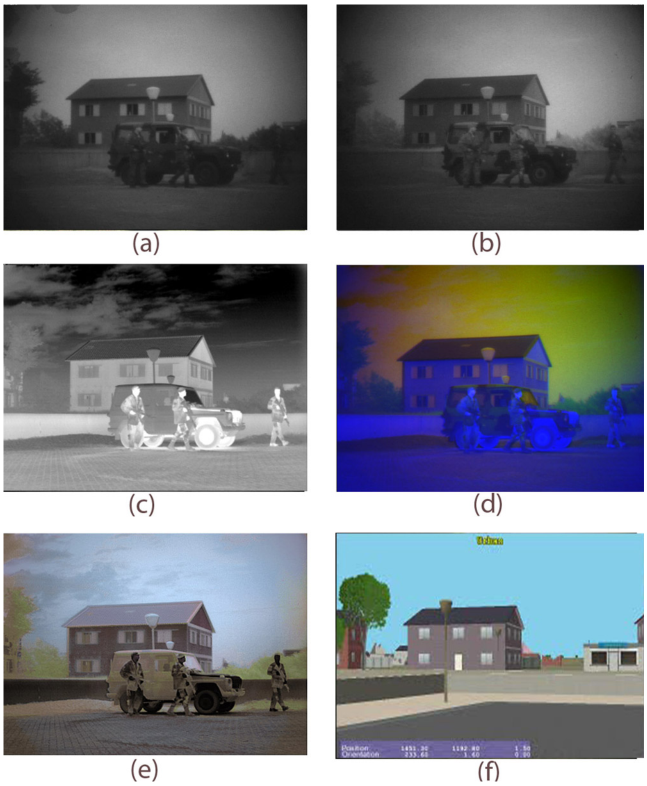

Figure 3. (a-c) Visual, near-IR, and long-wave IR night-time images of the same scene. (d) False color image obtained from (a-c). (e) Image (d) after replacing the color table of (d) by that of a corresponding synthetic scene (f).

facilitate the detection of persons and vehicles in a scene. The inherent color constancy provided by the method gives dynamic imagery a stable appearance when the sensor suite pans over or moves through a scene. By integrating a multi-band, night-vision system with a surveillance and observation system that generates real-time, synthetic 3D environment views from a geometric 3D scene model, we were able to demonstrate that the use of synthetic imagery also serves to derive appropriate color mappings (see Figure 3).[8]

The color remapping procedure was initially developed to colorize multi-band, night-vision imagery. However, since the method can be applied to enhance specific image details, there are also law enforcement, surveillance, medical, and industrial applications. Going forward, we will use newly developed color image quality metrics to derive optimal mappings for each of these applications.

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