Habilitation Thesis – Cosmin Ancuti

-Abstract-

In this habilitation thesis are presented my research activity and the main academic results obtained after obtaining my PhD, from the second half of 2009 to date.

In the following are described the main directions of my research in image processing and computer vision fields: color-to-grayscale conversion, image dehazing, fusion-based enhancing techniques, preprocessing techniques for computer vision applications and enhancing underwater images.

Color-to-grayscale conversion refers to mapping three dimensional color information onto a single dimension while still preserving the original appearance, contrast and finest details. We present the main contributions of our effective decolorization algorithm that preserves the appearance of the original color image. Guided by the original saliency, the method blends the luminance and the chrominance information in order to conserve the initial color disparity while enhancing the chromatic contrast. As a result, our straightforward fusing strategy generates a new spatial distribution that discriminates better the illuminated areas and color features. Since we do not employ quantization or a per-pixel optimization (computationally expensive), the algorithm has a linear runtime, and depending on the image resolution it could be used in real-time applications. Extensive experiments and a comprehensive evaluation against existing state-of-the-art methods demonstrate the potential of our grayscale operator.

Image dehazing refers to the process of enhancing the visibility in images degraded by haze. In outdoor environments, light reflected from object surfaces is commonly scattered due to the impurities of the aerosol, or the presence of atmospheric phenomena such as fog and haze yielding images characterized by poor contrast, lower saturation and additional noise. In our work we developed an alternative approach to solving this challenging problem. Our technique is based on the remark that the distance from the observer to the scene objects is highly correlated with the contrast degradation and the fading of the object colors. More specifically, by an extensive study it has been disclosed an important difference between hazy and non-hazy image regions, by performing a per pixel comparison of the hue values in the original image to their values in a 'semi-inversed' image. This 'semi-inversed' image version is obtained by replacing the RGB values of each pixel on a per channel basis by the maximum of the initial channel value (r, g or b) and its inverse (1−r,1−g or 1−b), followed by an image-wide renormalization. This observation has been validated on a large set of images, and allows for the detection of the hazy image regions by applying only a single simple operator.

Fusion-based enhancing techniques. Image fusion is a fundamental technique that blends data from multiple sources and has been successfully applied in different fields. We introduced two novel fusion-based enhancing techniques. Firstly, in our previous work we presented a fusion-based strategy to decolorize images accurately. The algorithm employs the three independent RGB channels and an additional image that conserves the color contrast, based on Helmholtz-Kohlrausch effect, as image inputs. This fourth input better preserves the global appearance of the image, as it enforces a more consistent gray-shades ordering. Our algorithm uses three weights based on three different forms of local contrast: a saliency weight map (which assesses the saliency of the input); a second weight map that advantages well-exposed regions; and a chromatic weight map (which increases color contrast in addition to the effect of H−K (Helmholtz-Kohlrausch) input). This approach is designed in a multi-scale fashion, using a Laplacian pyramid

representation of the inputs combined with Gaussian pyramids of normalized weights. Secondly, in our recent work we introduced a novel single image strategy that is able to accurately dehaze images using only the original degraded information. Our approach is based as well on a fusion strategy that takes two inputs derived from the original image. These inputs are weighted by three normalized weight maps and finally blended in a multi-scale fashion that avoids introducing artifacts. The method is fast being straightforward to implement and shows to outperform the related operators. Our approach performs an effective per-pixel computation that reduces the amount of artifacts compared with the patch-based methods.

Preprocessing techniques for computer vision applications. Firstly, in our previous work we introduced a decolorization technique that is suitable to match images based on local feature points. Besides performing a perceptually accurate color mapping, our technique focuses to increase as well the local contrast by manipulating effectively the chromatic information. We perform an extensive evaluation of the several recent SIFT-derived local operators in context of image matching when the camera viewpoint is varied and images are differently decolorized based on several recent grayscale operators. Secondly, we described a technique that is able to estimate the depth from a single image using user interaction. Starting from absolute depth constraints as well as surface normal constraints, we optimize for a feasible depth map over the image. We introduce a suitable smoothness constraint that respects image edges and accounts for slanted surfaces. We illustrate the usefulness of our technique by several applications such as depth of field reduction and advanced compositing.

Enhancing Underwater Images. We describe a technique published in our work that is able to enhance underwater images. It aims to yield a final image that overcomes the deficiencies existing in the degraded input images by employing several weight maps that discriminate the regions characterized by poor visibility. The extensive experiments demonstrate the utility of our solution since the visibility range of the underwater images is significantly increased by improving both the scene contrast and the color appearance.