Title: Specular highlight removal for endoscopic images

Trainee Name: Wenyao Xia

Supervisor(s): Dr. Terry Peters

Structured Abstract:

Introduction: Stereoscopic endoscopes have been used increasingly in minimally invasive surgery to visualize the organ surface and manipulate various surgical tools. However, due to the glossiness of the organ surfaces and the closeness of the light source, the endoscopic images are always corrupted by high amount of specular highlight. The presence of specular highlight would severely occlude the organ surface and affect other computer assisted algorithm such as stereoscopic surface reconstruction. To address this problem, we propose a specular highlight removal algorithm based on dichromatic model to recover and interpolate the specular highlight corrupted image regions.

Methods: The proposed method is mainly consisted of two parts. In the first part, the true color of the pixel is estimated using non-local means method, where the non-local weight function is determined by distance, hue similarity, and minimum intensity of pixel color channel. In the second part, the magnitude of the de-specularied image is obtained via a variational framework with L2 and L1 regularization. A dual formulation is also proposed to solve the optimization problem with good efficiency. The experimental results are validated through visual inspection, improve signal to noise ratio (PSNR), and disparity map accuracy.

Results: The proposed method is tested on synthetic benchmark images for specular highlight removal as well as stereoscopic image data set created by Lena Maier-Hein in 2014. Qualitatively, the proposed algorithm has achieved a significant improvement in terms of visual inspection. Most of the specular highlights are removed from the image with minimum color distortion. Quantitatively, the proposed method yields comparable PSNR value (35 dB in average) for synthetic images. The disparity map accuracy is yet to be estimated.

Discussion: The proposed specular highlight removal algorithm is able to effectively remove large amount of specular highlight from endoscopic images. Through visual inspection, not only the proposed method is able to obtain higher quality results, it is also able to overcome other challenges such as color noises, pixel saturation, and blooming artifact. This would improve the accuracy of 3D surface reconstruction and enable more accurate surgical planning and guidance. However, the algorithm seems to over-penalize the whiteness of the image and cause relatively larger color distortion for images containing high amount of natural whiteness. A grey-pixel correction scheme is now under development based on the saturation change of images.