学　位　論　文　内　容　の　要　旨

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学　位　論　文　題　名

Real-time Contrast Management in Digital Images using Local Histogram Equalization Filter
（デジタル画像における局所ヒストグラム平均化を用いたリアルタイムコントラスト調節手法）

Growing demand for displays with superior quality and higher resolutions has been continuously driving the high dynamic range market. The advances made in high dynamic ranging techniques and availability of suitable hardware platforms to run these algorithms has found applications in AR-VR, gaming, medical, security and many other computer vision related areas. This thesis presents both hardware and software contributions in the field of high dynamic range imaging by designing, implementing and analyzing a smoothed local histogram equalization algorithm.

The proposed global and locally adaptive tone mapping algorithm is inherently fast in execution and can process full HD images and output video at 60 frames per second. Our LHE based algorithm controls global and local characteristics individually. In contrast to other tonemap operators, our algorithm manages light or dark halos separately and by using local tonemap function alone, it can effectively suppress noise. Traditionally, tone mapping algorithms operate on luminance channels which can lead to some loss of information. We minimized this data loss by employing a human perception-based color to luminace mapping scheme. We proposed a lightweight and high-speed image decolorization method based on human perception of color temperatures. Our grayscale conversion demonstrates that warm colors are lighter than cool ones by using a blending function with R and B channel weighting. Our optimal color conversion method produces luminance in images that are comparable to other state of the art methods. We validated this by a user study and found that our color to luminance mapping achieves effective luminance distribution and is very suitable as a pre-processing step for tone mapping application, thereby making our TMO operator ideal for many practical applications.

Our smoothed LHE algorithm operates with large kernel size and forms sawtooth like edges which is useful for processing images with optical illusions in them. We thoroughly analyzed state of the art edge preserving filters for processing these images with illusion and find they have certain inherent limitations which causes them to produce images with over emphasized edges. Digital X-rays are low contrast images which are also known to have optical illusions like Mach bands and background contrast effects, which are caused by lateral inhibition phenomena. We observe that using multilayer (ML) methods with latest edge preserving filter for contrast enhancement in medical images can be problematic and could lead to faulty diagnosis from detail exaggeration which are caused by uncontrolled texture boosting from user defined gain settings. ML filters are designed with few subjectively selected filter kernel sizes, which can result in unnaturalness in output images. We analyzed, and report that our smoothed LHE filter with an adaptive gain control, is more robust and can enhance fine details in digital X-rays while maintaining their intrinsic naturalness. Preserving naturalness in X-ray images are an essential feature for radiographic diagnostics. Our proposed SLHE filter has O(1) complexity

and can easily be controlled and operated with a continuously varying kernel size, which functions like an active high pass filter, amplifying all frequencies within the kernel.

The contributions presented in this thesis can be viewed as setup for full HDR pipeline. This thesis work helps in realizing an efficient hardware implemented smoothed LHE tonemap operator for natural appearing display. We have performed multiple subjective user studies to validate our algorithm's effectiveness in retaining perceptual match.