Chapter 8
Conclusion and Future Work

In conclusion, this chapter presented an in-depth analysis of color spaces for detecting specular reflection in smart colposcopy images. Through careful examination, the RGB and XYZ methods emerged as the most suitable choices, considering the significance of preserving original colors for accurate naked-eye analysis. Using the intensity-based threshold method, the proposed approach successfully identified glare regions in smart colposcopy images. The qualitative analysis revealed the superiority of the proposed XYZ method over the RGB method in accurately identifying specular reflection while maintaining color appearance during the reflection process. This critical distinction ensured that the enhancement process did not alter the image's visual characteristics, enabling better interpretation by medical professionals. Furthermore, the proposed method's versatility extended beyond smart colposcopy images, proving effective in identifying glare regions across other medical imaging domains, such as digital colposcopy, endoscopy, and colonoscopy images. The chapter introduced a threshold-based approach for generating annotated images to facilitate deep learning-based segmentation. This process created a foundation for accurate and reliable segmentation, enabling the subsequent identification of different regions of interest within the images. UNet++ emerged as the top performer among the evaluated segmentation models, displaying exceptional accuracy and Intersection over Union (IoU) metrics in segmenting glare regions within smart colposcopy images. Fine-tuning the UNet++ model further enhanced its performance, increasing its suitability for glare segmentation and ensuring precise identification of these crucial areas. Additionally, the chapter introduced the proposed bilateral convolutional inpainting model, which proved highly effective in removing glare regions and desired objects from various images. The model seamlessly filled the removed regions with high-quality pixels, resulting in natural-looking restorations. Extensive testing across different datasets, including Place 2, the Open Logo dataset, and satellite images, consistently demonstrated the model's reliability and success in removing specified objects and restoring neighboring regions. The model predicted missing pixel values in larger masked areas, outperforming other deep learning inpainting methods. In summary, the chapter showcased a promising set of methods for enhancing smart colposcopy images, accurately detecting specular reflection, and ultimately improving cervical cancer grading accuracy. The proposed approaches held substantial potential and offered valuable insights for future research in smart colposcopy image analysis and medical imaging applications. By addressing the identified limitations and continuing to refine the techniques, these methods could pave the way for significant advancements in medical imaging, cancer detection, and other related fields.

In addition to the current findings, the conclusion opened up several avenues for future research and enhancements. The enhancement of smart colposcopy images played a vital role in improving the accuracy of cancer grading. Specular reflection, a common issue in these images, needed to be detected and removed for better image quality. In this regard, a proposed method utilized a U-Net model with binary masking to accurately recognize the SR regions caused by specular reflection. Additionally, bilateral-based convolutional inpainting was employed to replenish the eliminated portions, ensuring complete image restoration. This augmentation procedure can greatly increase the accuracy of the three phases of cancer classification. To evaluate the effectiveness of the enhancement, three classification models, namely DenseNet121, EfficientNet, and VGG19, were utilized. The prediction accuracy of each model increased when grading cervical cancer using the enhanced images. Notably, the proposed binary masking technique was not limited to images alone; it could also predict SR regions in other medical images acquired through digital tools. However, there were certain limitations associated with the proposed work. Sometimes it was necessary to distinguish between SR and the speculum examination instrument utilized in smart colposcopy images. Furthermore, since the smart colposcopy device is typically equipped with a fixed flashlight, the images often have consistent illumination. The accuracy of the range selection for SR region recognition may be impacted if the image's lighting changes. This limitation was recognized in the proposed recognition of SR.

In future research, exploring how the image enhancement process can improve the method for detecting cancer on intelligent colposcopy images is essential. By further investigating the impact of enhancement techniques on the accuracy and efficiency of cancer detection, researchers can gain insights into potential advancements in the field. In summary, the proposed method of enhancing smart colposcopy images by detecting and removing specular reflection using binary masking, fine-tuned U-Net++ models, and bilateral convolutional inpainting has shown promising results in improving the grading accuracy of cervical cancer. However, certain limitations regarding identifying specular reflections and consistent illumination must be addressed. Future research should focus on the application of enhancement techniques in the cancer detection process to further advance the smart colposcopy image analysis field.