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題目(和文)	敵対的生成ネットワーク(GAN)を用いたドメイン適用技術の医用画像処理への応用に関する研究
Title(English)	Study on Generative Adversarial Network (GAN) based Domain Adaptation for Advanced Medical Image Processing
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Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	情報通信　系 ライフエンジニアリング　コース	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of　(Engineering)
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

The thesis with title "Study on Generative Adversarial Network (GAN) based Domain Adaptation for Advanced Medical Image Processing" consists of 7 chapters.

Chapter 1 "Introduction" includes the background, motivations, and objectives of this work. It also describes the novelty of our research. Though using deep learning for image processing has various advantages, for example, high accuracy, robustness and so on, it requires large number of labeled data for obtaining efficient performance. In clinical study, integrated information of images having different properties has very significant implications. Methods for obtaining such properly aligned multi-domain images are highly dependent on the availability of large-scale labeled data. Obtaining such labeled data is laborious and expensive. This study aims to reduce the dependency on the large-scale paired training data by adopting unsupervised CycleGAN based domain adaptation technique for advanced medical image processing such as stain conversion, registration, and detection of GGO lung nodule.

Chapter 2 "Theoretical Background" presents some general theoretical background which are closely associated with this dissertation. Domain shift problem has been defined at first. Then, we have explained how domain adaptation techniques reduce the adverse effect of domain shift problem and contribute to improve the model performance. This chapter also includes the basic methodology of GAN and Conditional GAN (CGAN) which is the base of CycleGAN.

Chapter 3 "Domain Adaptation with CycleGAN" describes the architecture and methodology of CycleGAN (Cycle Generative Adversarial Network). Then, it presents previous research where CycleGAN has been utilized for domain adaptation in different medical image processing applications. Next, we have also discussed the limitation of the current approaches and future scopes of CycleGAN to be applied for more advanced applications.

Chapter 4 "Staining Conversion with CycleGAN" describes our first experiment where we have investigated the effectiveness of deploying CycleGAN for digital stain conversion. Previous studies show that abnormality of elastic fiber is highly correlated to different diseases. Though H&E staining is the most used staining technique, it cannot differentiate elastic and collagen fiber because of their similar color and pattern. In hospitals, EVG staining is used for observing elastic fiber which is very expensive and time consuming. This study proposes a two-step GAN based method for generating RGB EVG stained image from hyperspectral H&E stained image so that cost and time of conventional EVG staining can be reduced.

The dataset involves H&E stained hyperspectral image (HSI of 61 channels) and RGB EVG stained image (3 channels). At first, the CycleGAN model is trained with a large-scale (9800) unpaired data (unsupervised) and in the second step, the generator HE-to-EVG is re-trained with a small-scale (772) paired data (supervised). As we have utilized the complete spectral information of the HSI, we had to calculate the identity loss explicitly. To do so, we obtained a set of three basis function that retained the important features of HSI within the reduced dimension. From the experimental result it has been observed that our proposed method outperformed state-of-the-art methods in generating realistic EVG stained image with better identification of elastic and collagen fibers.

Chapter 5 “Improving Registration Accuracy using CycleGAN” investigates the effectiveness of leveraging CycleGAN based domain conversion technique for improving the accuracy of spatial registration between heterogeneous stained histopathological images. The proposed methodology involves domain conversion as preprocessing step and SURF feature-based image registration. As the proposed method is unsupervised and leverages hand crafted features, it has nullified the dependency on prior aligned paired training data. We tested 85 pair of images obtained from four different tissue slides. The experimental results have shown that the proposed method has obtained 4% improvement in the image alignment than the baseline method.

Chapter 6 “Domain Adaptation for Data Augmentation of Rare Cases (for GGO Nodule Detection)” investigates the effectiveness of applying CycleGAN based domain adaptation for the detection of GGO lung nodules. As GGO nodule is less frequently found than non-GGO, this study improves the training data quantity by adapting the domain of non-GGO to GGO and vice-versa. The deep learning model has been trained with both original and augmented data. The results show more than 10% at FP/S 0.125 and overall, 2% improvement with our proposed method than the baseline one. As our proposed data augmentation technique only change the nodule type without modifying its original location, the original annotation information can also be used for augmented data.

Chapter 7 “Discussion and Conclusion” discusses the significance, limitations and future scopes of this research and concludes this dissertation. The proposed method can be very useful for other types of medical image modalities for example, MRI, X-ray, macropathology and so on. The experimental results prove the effectiveness of applying CycleGAN based domain adaptation technique for stain conversion, image registration and GGO lung nodule detection while alleviating the dependency of deep learning model on the availability of large number of labeled training data.