公立千歳科学技術大学紀要第 3 巻第 1 号 (2022)
大学院理工学研究科理工学専攻博士前期課程 令和 3 年度修士論文英文要旨

Discrimination-performance evaluation of arteries and veins in ultrasound images by data augmentation using GAN

Kotaro INOUE（井上虎太郎）

There are high expectations for AI application studies for image analysis in medicine. CT, MRI, and ultrasound are the most common medical imaging methods. Ultrasound images are unclear, and healthcare professionals have difficulty identifying the organs. As a result, it is desirable to build an AI-based assistance application to identify organs in ultrasound images. There is a problem with developing a highly effective support system because many actual ultrasound images and attribute data are required. We think that a Generative Adversarial Network (GAN) is an effective solution for this problem. Therefore, extending the training data by adding data generated by GAN is expected to improve the accuracy of AI. This study applies GAN to data augmentation using GAN to ultrasound images with a small number of arteries and veins and aimed to evaluate the accuracy of arteries and veins discrimination with and without data augmentation.

In this study, we collaborated with a professional nurse to collect ultrasound images. Arterial and venous labels were assigned to all ultrasound images during collection based on the expert nurses' judgment. We constructed two datasets: Dataset A, which contains 161 ultrasound images collected only from males in their 20s. The other is Dataset B, which contains images collected mainly from men and women in their 80s and contains 66 data. These two datasets were used in the experiments to evaluate the accuracy with and without data augmentation. To unify a series of processes from AI training to evaluation, and to enable quantitative evaluation under the same conditions, we built an application using two AIs: one for data augmentation (DA) and the other for discriminating arteries and veins (OD). In this study, we used Conditional GAN[1] and EfficientDet[2], respectively. Intersection Over Union (IoU) and Average Precision (AP) were used as evaluation indices for discriminating arteries and veins. In addition, since the number of data used for AI was small, five evaluations were conducted using K-split cross-validation with K being 5. The results for the three datasets “A”, “B”, and “A and B” are shown in Table 1. From the table, we can see that by applying DA(x1), only A takes high accuracy, setting the size of the dataset is doubled. This indicates that Dataset B includes low-quality data. Then we investigated the effect of data augmentation in dataset A, changing the threshold of intersection degree in between the correct and predicted boxes in the IoU. Specifically, the accuracy of the evaluation indicator, IoU, was evaluated from IoU = 0.10-0.70 in increments of 0.10, considering that the standard could be lowered in the case of location identification only. As a result, we confirmed the same improvement in accuracy as in the first experiment. However, the trade-off between the accuracy and the threshold was not so effective. To improve the accuracy further, we evaluated the case where the filter was applied to the ultrasound images. We observed that the accuracy was dropped when the data extension was applied to the entire dataset but improved when the filter was applied to the images generated by GAN, in comparison with the case without the filter. The results showed that data augmentation using GAN was effective in improving the performance of arteries and veins discrimination in ultrasound images, even for small datasets, by filtering and denoising the images generated by GAN if the dataset was not biased to some extent.

Table 1. Results of Dataset "A", "B" and "A and B".

	Dataset A	Dataset B	Dataset A and B
Base	0.220	0.129	0.251
Base + DA($\times$ 1)	0.288	0.065	0.224

[1] Mingxing Tan, Ruoming Pang and Quoc V. Le. EfficientDet: Scalable and Efficient Object Detection; arXiv:1911.09070.

[2] Mehdi Mirza and Simon Osindero. Conditional Generative Adversarial Nets, 2014; arXiv:1411.1784.