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Comparison of Image Augmentation Techniques in Urinary Bladder Cancer Diagnostics

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Abstract

Urinary bladder cancer is one of the most common malignancies in the urinary tract. One of the key challenges in medical image analysis is the curation of sufficiently large data sets. For these reasons, in this paper, two different approaches for image data set augmentation are presented. One approach is based on a pipeline that consists of various geometrical variations of original images. The second approach is based on the utilization of Generative Adversarial Networks (GAN). Such an approach is used to artificially create new images that are used to increase the volume of the training data set. The performances were investigated by using urinary bladder cancer data set. From the achieved results, it can be concluded that by applying image augmentation techniques, significantly higher results are achieved. Furthermore, it can be concluded that by applying GAN-based augmentation, even higher results ara achieved.

Key words: CNN, data set augmentation, GAN, urinary bladder cancer

1 Introduction

Urinary bladder cancer is one of the most common malignancies in the urinary tract [1, 2]. One of the key diagnostic procedures for urinary bladder cancer diagnosis is cystoscopy. The aim of the cystoscopic procedure is a visual evaluation of the urinary bladder mucosa and biopsy of tissue in focus. Such a process can be painful and time-consuming [3]. For these reasons, the new procedure, the optical biopsy is introduced. The aim of optical biopsy is to use a confocal endomicroscopy to perform an in-vivo evaluation of urinary bladder mucosa [4]. The main limiting factor for wide usage of optical biopsy is low accuracy of recognition of particular cancer grades, such as carcinoma-in-situ [5]. For these reasons, AI algorithms are introduced to increase the accuracy of urinary bladder cancer grade recognition using optical biopsy. Curation of sufficiently large image data sets is often challenging, particularly in biomedical fields. For these reasons, it is necessary to implement image augmentation techniques with aim of artificially increasing training data sets. In this research, two different image augmentation techniques are developed. The first image augmentation technique is augmentation based on geometrical variations of the original image. The other approach used in this research is the utilization of Generative Adversarial Networks (GAN), a system based on two convolutional neural networks [6]. In this paper, a comparison of two aforementioned data augmentation techniques is presented.

2 Description of augmentation techniques

The first image augmentation technique is augmentation based on geometrical variations of the original image. Such a technique is based on the utilization of an augmentation pipeline that contains all available image variation procedures. According to the value of a random variable, the operation is executed. In a described way, multiple different image variations are applied on the same image, reducing the possibility for the occurrence of two same images in the training data set. The schematic representation of an augmentation pipeline is given in Figure 1.

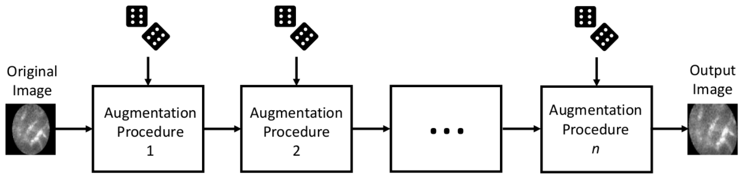


Figure 1: Augmentation pipeline for the case of geometrical image variations

The other approach used in this research is the utilization of Generative Adversarial Networks (GAN), a system based on two convolutional neural networks. The GAN-based approach is used to artificially generate new images that represent a particular class. A detailed procedure of GAN utilization for image generation is presented in [6]. It is important to emphasize that images produced by GAN are not geometrical variations of original images, but rather new, artificially generated images. The schematic representation of the image-generating procedure is presented in Figure 2.

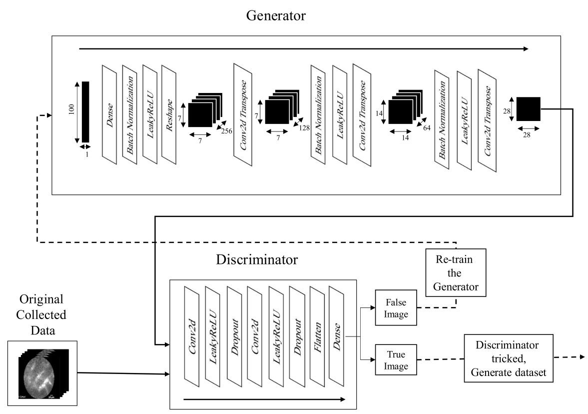
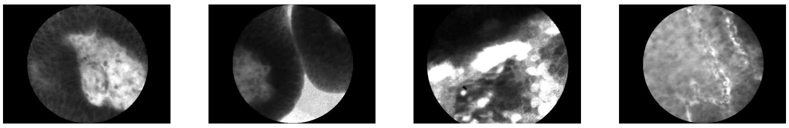


Figure 2: Schematic representation of GAN procedure for image generation

3 Materials and methods

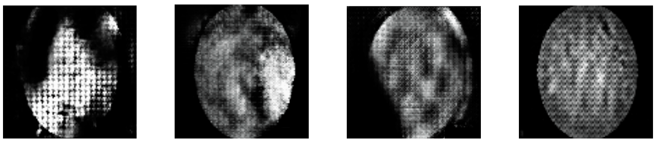
In this research, a data set that consists of 2525 images of the urinary bladder mucosa, is divided into four classes (healthy mucosa, high-grade cancer, low-grade cancer, carcinoma-in-situ). An example of each image class is presented in Figure 3.



(a) High grade carcinoma (b) Low grade carcinoma (c) Carcinoma in-situ (d) Healthy mucosa

Figure 3: Overview of bladder mucosa images obtained with cystoscopy

On the other hand, GAN generated images for each class are presented in Figure 4.



(a) High grade carcinoma (b) Low grade carcinoma (c) Carcinoma in-situ (d) Healthy mucosa

Figure 4: Overview of generated bladder mucosa images

To classify images, in this research AlexNet [7] and VGG-16[8] CNN architectures are used. This CNN architectures represent standard deep CNN models used in various tasks of image recognition [9]. The networks are evaluated by using ROC analysis and 5-fold cross-validation. By using this approach, both classification ($\overline{AUC_{micro}}$) and generalization ($\sigma(AUC_{micro})$) performances are evaluated.

4 Results and Comparison

When the results achieved on both architectures are compared, it can be noticed that by applying the augmentation techniques and increase in $\overline{AUC_{micro}}$ and a decrease in $\sigma(AUC_{micro})$ can be noticed. For these reasons, it can be concluded that by applying the augmentation techniques and increase in classification and generalization performances can be noticed regardless of CNN architecture utilized. Furthermore, it can be seen that in the case of GAN-based augmentation, even higher classification and generalization performances are achieved, as presented in Figure 5.

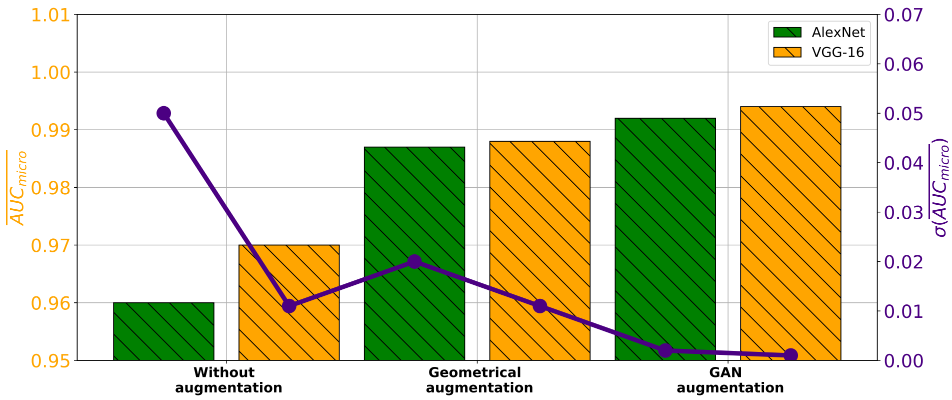


Figure 5: Comparison of the obtained results

5 Conclusions

In this article, the authors have presented two different approaches to image data set augmentation, one based on geometrical variations and the other based on GAN. From the presented results, it can be noticed that a significant increase in both classification and generalization performances is achieved, regardless of CNN architecture used for classification. Furthermore, it can be seen that by applying GAN-based augmentation, even higher performances are achieved. The presented results are pointing towards the conclusion that on this, or similar problems, GAN-based augmentation should be used to increase the CNN performances.

Acknowledgments

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