Performance analysis of GAN approaches in the portable chest X-ray synthetic image generation for COVID-19 screening

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Abstract. This manuscript presents a performance analysis of chest X-ray synthetic image generation for COVID-19 screening. The proposed system translates chest X-ray images from Normal to COVID-19 and vice versa, without needing paired data, representing a powerful data augmentation approach. To this end, we analyze the performance of 3 representative state of the art architectures for image translation, assessing the impact of oversampling on improving the performance of automatic COVID-19 screening.

Keywords: Computer-aided Diagnosis, Portable Chest X-ray, COVID-19, Deep Learning, Synthetic Image Generation

1 Introduction

COVID-19 is a highly infectious disease that represents a great challenge for the worldwide health care services. It mainly affects the pulmonary regions and, therefore, chest X-ray imaging is an useful visualization technique to study the severity of the pathology in every patient. Moreover, in the context of the global pandemic, it is critical to cut chains of transmission and, as the portable chest X-ray devices are easier to decontaminate, radiologists are asked to give preference to this kind of capture devices instead of the fixed machinery.

Data scarcity is a critical aspect in many biomedical imaging domains and is even more accused in this context due to the recent emergence of the disease. Image generation represents a powerful approach to artificially augment the dimensionality of a particular chest X-ray imaging dataset. This data augmentation strategy can improve the performance of other related tasks, as the automatic COVID-19 screening. This image generation can be performed using image translation models, *i.e.*, models that can convert images from a certain domain to another domain (a typical example is the translation model that is able to convert a summer landscape to a winter landscape and vice versa).

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2 Methodology

In this work, we analyze the performance of 3 representative state of the art image translation models for portable chest X-ray image generation for the COVID-19 screening: the Cycle-Consistent Adversarial Networks (CycleGAN), the Contrastive Unpaired Translation (CUT) and an implementation of a conditional GAN denoted as Pix2Pix model. To this end, we use a dataset provided by the Complexo Hospitalario Universitario de A Coruña (CHUAC) specifically designed for this study, consisting of 797 Normal control cases and 2,071 COVID-19 cases. The methodology followed to study the performance of chest X-ray image generation is divided into 2 main parts. In the first part of the methodology, the models are trained to translate between the 2 main scenarios of reference: Normal to COVID-19 and COVID-19 to Normal. For the second part, the trained models are used to perform the synthetic image generation. The image translation is performed in both directions as it can be seen in Fig. 1. For the first direction, Normal images are converted to their representation with COVID-19 and, for the second direction, COVID-19 images are converted to their Normal version.

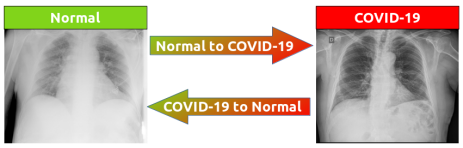

Fig. 1. Diagram of the image translations that are performed.

3 Results and Conclusions

Overall, the developed system achieved satisfactory results, generating realistic synthetic portable chest X-ray images. In the same way, the translation models are able to synthesize well defined differences in pulmonary regions, which are the most important parts of the images, where the COVID-19 is mainly shown. The novel sets of images can be used as a data augmentation strategy to improve the performance of related tasks, as the automatic COVID-19 screening.

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