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Computational Radiological Screening of Patients with COVID-19 Using Chest X-ray Images from Portable Devices †

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Abstract: This work presents a fully automatic system for the screening of chest X-ray images from portable devices under the analysis of three different clinical categories: normal, pathological cases of pulmonary diseases with findings similar to those of COVID-19, and COVID-19 cases. Our methodology was validated using a dataset retrieved specifically for this study, which was provided by the Radiology Service of the Complexo Hospitalario Universitario A Coruña (CHUAC). Despite the poor quality conditions of chest X-ray images acquired by portable devices, satisfactory results were obtained, demonstrating the robustness and great potential of the proposed system to help front-line clinicians in the diagnosis and treatment of patients with COVID-19.

Keywords: computer-aided diagnosis; portable chest X-ray imaging; COVID-19; pneumonia; deep learning

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1. Introduction

COVID-19 is a disease caused by a new severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which was initially identified in Wuhan (capital of the Hubei province, China) in early December 2019. The World Health Organization (WHO) declared the COVID-19 outbreak a global pandemic on 11 March 2020. According to the WHO, more than 187 million cases have been confirmed, including more than 4 million deaths, making it one of the deadliest pandemics in history. Moreover, this highly infectious disease has the potential to mutate and infect non-immune populations [1].

According to the American College of Radiology (ACR), portable chest X-ray devices should be used instead of conventional fixed machinery in order to prevent the spread of the COVID-19 pathogen, which is considered critical in this pandemic scenario [2]. A portable X-ray device is a compact equipment that allows the clinician to perform radiological examinations of the patient in a hospital bed or the emergency room. In this type of device, the X-ray tube is connected to a flexible arm that extends over the patient, while a radiographic image recording plate is placed under the patient to facilitate the imaging process. In this context, chest X-ray images acquired with portable devices are widely used by clinicians to assess confirmed, suspected, and probable cases of COVID-19 disease from data collected directly on site, without the necessity of transferring potentially COVID-19-infected patients to another location, and thus preventing cross-contamination [3]. Despite its great importance and usefulness in the pandemic, the use of portable equipment implies a greater challenge for the automatic diagnosis of COVID-19, since the acquired images

are of a lower quality and a lower level of detail in comparison with the conventional fixed machinery.

2. Methodology

In this work, we present a fully automatic system for the screening of chest X-ray images from portable devices under the analysis of 3 different categories [4]: (I) normal, (II) pathological cases of pulmonary diseases with findings similar to those of COVID-19, and (III) COVID-19 cases. To analyze the differentiation between these 3 categories and explore the full potential of the available dataset, the proposed methodology integrates 3 complementary approaches: (I) normal vs. pathological/COVID-19, (II) normal/pathological vs. COVID-19, and (III) normal vs. pathological vs. COVID-19. Figure 1 shows representative examples of portable chest X-ray images related to the presented 3 clinical categories. To perform the classification process, we used a Densely Connected Convolutional Network (DenseNet-161) [5] architecture, which was adapted to our issue due to its flexibility and simplicity and its preceding promising results in other classification tasks [6,7].

(**a**) (**b**) (**c**)

Figure 1. Representative examples of portable chest X-ray images. (**a**) Portable chest X-ray images from normal patients. (**b**) Portable chest X-ray images from pathological patients without COVID-19 but diagnosed with other pleural or pulmonary diseases. (**c**) Portable chest X-ray images from patients with COVID-19.

3. Results and Conclusions

The dataset that was used for this research study has been provided by the Radiology Service of the Complexo Hospitalario Universitario A Coruña (CHUAC). Specifically, this dataset consists of 1616 portable chest X-ray images divided into 728 normal, 648 pathological, and 240 COVID-19 cases. All the images were inspected by specialist graders in order to find relevant features representative of pulmonary affectation and, in the case of the COVID-19 samples, this was corroborated by external RT-PCR tests. Despite the poor quality of the chest X-ray images that is inherent to the nature of the portable equipment, the presented approaches provided global accuracy values of 79.62%, 90.27%, and 79.86%, respectively. Complementarily, Figure 2 presents the confusion matrices with the experimental results of all the presented approaches. As we can see, all the results that were obtained show the robustness of the presented system in the classification of the three categories of chest X-ray images considered in this work.

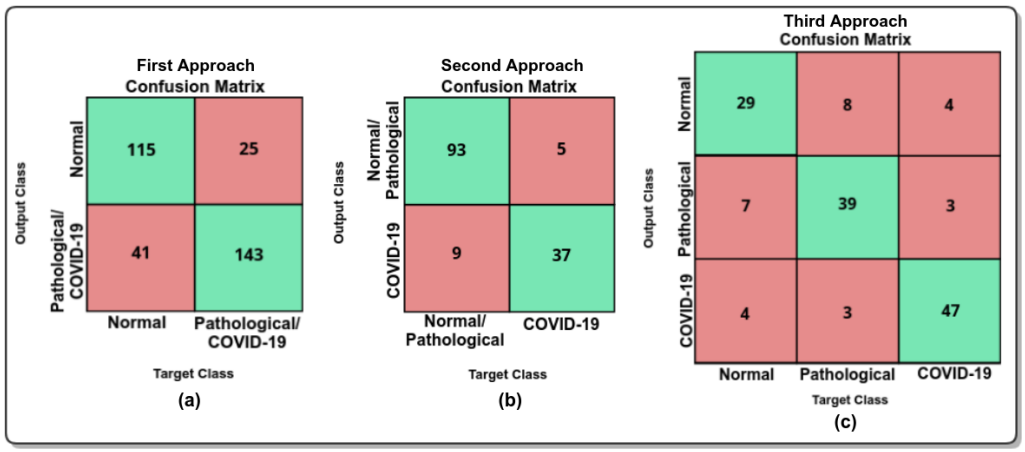

Figure 2. Experimental results of the proposed approaches for the classification of COVID-19 in portable chest X-ray images. (**a**) first experiment: analyzing the normal vs. pathological/COVID-19 approach. (**b**) second experiment: analyzing the normal/pathological vs. COVID-19 approach. (**c**) third experiment: analyzing the normal vs. pathological vs. COVID-19 approach.

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