Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Covid-19’s Rapid diagnosis Open platform based on X-Ray Imaging and Deep Learning
Mohamed Tabaa*, Hamza Fahmani, Mehdi El ouakifi, Hassna Bensag

Abstract

The Coronavirus epidemic first appeared in Wuhan-China on December, 31st, 2019. This has put the world's hospitals, clinics, testing laboratories and health administrations under pressure. As of April, 04th, 2020, the World Health Organization reported more than 167,515 confirmed cases in more than 100 countries worldwide. The diagnosis of the epidemic will increase the burden on overburdened testing laboratories. Several screening methods have been proposed in parallel in order to facilitate and, above all, to make rapid diagnosis easier. At this level, X-Ray images seem to be a good accompanying solution for emerging countries to help rapid screening. The solution proposed in this paper consists on a collaborative and smart platform based on the Convolutional Neural Network for Classification and Detection namely VGG16. The platform ensures the fast download of the X-Ray image, with the entry of the patient’s personal information followed by the launch of a 5 seconds test. The platform generates, as a result, a PDF file containing all patient information.

© 2020 The Authors. Published by Elsevier B.V.
This is an open access article under the CC BY-NC-ND license (https://creativecommons.org/licenses/by-nc-nd/4.0)
Peer-review under responsibility of the Conference Program Chairs.

Keywords: Deep Learning, X-Ray Image, VGG16, CNN, Covid19, Open platform

1. Introduction

We are all aware of the weak health systems in Africa and that the pandemic is increasingly spreading in this continent characterized by its youth. Despite the fact that Africa is the least impacted continent in the world, today, it faces the spread of the coronavirus affected 50 African countries. The first case of coronavirus was declared in Egypt...
on February 14th. At this level, the World Health Organization is sounding the alarm and fears that Africa will not be able to withstand the spread of the pandemic and calls on all Africa to wake up and prepare for the worst.

In 3 April 2020, Morocco recorded 761 confirmed cases of Covid-19, including 47 deaths (it should be noted that the Moroccan authorities have imposed a containment and restrictions on sporting and cultural events). In Algeria, 1171 confirmed cases are reported with 105 deaths (the country has suspended all its links with European countries and Middle East capitals). In Tunisia, the figures are 495 confirmed cases with 18 deaths (the population is now confined until April 20. Only 11 cases have been registered in Libya (Libya International Airport is closed). Egypt records 865 confirmed cases and 58 deaths [1,2 and 3].

In order to carry out coronavirus screening, the diagnostic test PCR (Polymerase chain reaction) must be performed. This test consists of a nasopharyngeal swab, which must be taken by a doctor or nurse via a small swab that is inserted into the nose. For coronaviruses, the test can also ensure through a sample from the lower respiratory tract. Thus, the test is then analyzed by a specialized laboratory to look for the presence of genetic material of the coronavirus and thus confirm the diagnosis [4]. In order to minimize the burden on specialized laboratories, we propose in this paper a diagnostic solution via X-Ray images. This test (which is not yet confirmed by health institutions) is based on an intelligent platform on which, after taking the R-Ray image, the user downloads the image and then launches the test which will take 5 seconds. The platform is based on an artificial intelligence model (Deep Learning) based on the VGG16 model. After testing, the platform generates a PDF document that will be sent to health institutions for better decision making. The platform will also give users a visibility on the state of the country as follows: Confirmed cases, cured and deceased cases as well as safety instructions and measures to better manage suspicious cases.

The paper will be detailed as follows: in the second part we detail the database used as well as the detection and classification model used. The discussion and the results will be the subject of the third part and towards the end a conclusion.

Fig. 1. Example of X-Ray images for the two cases Normal and Covid19

2. Methods

A. Dataset

Although PCR tests offer many advantages and above all reliability, radiology (x-ray images) can be used to help screen patients. The main focus of the work is the use of X-ray images for the development of artificial intelligence-based approaches to predict infections. To do so, we should have the necessary images (especially open databases) to ensure good decision making via AI models. The database we have used in this research work requires actual of
COVID-19 cases with chest X-rays or CT images. These may be COVID-19 cases for MERS, SARS and ARDS cases. Through this database we were able to collect 100 images of confirmed COVID-19 cases and we also collected 100 images of normal cases. Figure 1 shows some X-Ray images of the two cases: normal X-Rays and X-Rays of patients with Coronavirus [7].

B. VGG16 model

The VGG-16 is a convolutional neural network (CNN) architecture developed by Karen Simonyan and Andrew Zisserman from the Oxford Robotics Institute. This architecture is the result of participation in the Large Scale Visual Recognition Challenge in 2014, where the model achieved 92.7% accuracy in the 5 imageNet tests (a very large platform with 14 million hand-annotated images of what is in the image) [6].

The VGG16 is an intelligent architecture not relying on a very large number of hyper parameters, but rather on 3×3 filter convolution layers with a pitch of 1, using the same padding and the same 2×2 filter maxpool layer with a pitch of 2, and it consistently follows the convolution and max pool layer arrangement throughout the architecture. VGG16 is a fairly large network containing about 138 million parameters, i refers to 2 fully fully-connected (FC) followed by a Softmax directly to the output. As for the number 16, it refers to 16 layers that have weights (figure2).

3. Discussion

The idea of this collaborative project is the design of an intelligent and open platform to assist health authorities in screening for COVID-19 during this health crisis. It involves the deployment of artificial intelligence and chest X-ray images for an initial detection of suspicious and critical cases and above all to minimize the burden on testing laboratories. COVID-19 causes pneumonia, lungs inflammation and possibly attacks the respiratory tract, so it is essential to think about making chest X-ray images which will be useful to know, initially, whether the patient is a confirmed case or not. To do this, we used a database of COVID-19 radiology images based on the images published in [7].

We started by extracting data from SARS, MERS and ARDS and then constructing the different radiology views to construct 100 actual images of COVID-19 cases. At the same time, we also collected data from healthy people and people with other diseases building up a 100 images dataset of concerned subjects.

In this work we used the extensive learning library TensorFlow 2.0 and Keras through a selection of tensorflow.keras imports. In particular we used the Scikit-learn and Matplotlib libraries for learning and pre-processing the images in the database we built up. In order to adapt the image to the standards required by the VGG-16 architecture, we reconfigured the images by changing the color from BGR to RGB and especially resizing the images
to (224,224) as the used VGG-16 model takes into account a 224*224*3 pixels image. We have changed the label of
the images in both the label list and the database and adapted them to the pixel scale in the range [0,1] to facilitate
training and then an adaptation to the Numpy Array format (figure3).

Table 1. Parameters of our model

| Layer (type)          | Output Shape         | Parameters |
|-----------------------|----------------------|------------|
| Input_1 (InputLayer)  | (None, 224, 224, 31) | 0          |
| Block1_conv1 (Conv2D) | (None, 224, 224, 64) | 1792       |
| Block1_conv2 (Conv2D) | (None, 224, 224, 64) | 36928      |
| Block1_Pool (MaxPooling2D) | (None, 112, 112, 64) | 0          |
| Block2_conv1 (Conv2D) | (None, 112, 112, 64) | 73856      |
| Block2_conv2 (Conv2D) | (None, 112, 112, 128)| 147584     |
| Block2_Pool (MaxPooling2D) | (None, 56, 56, 128) | 0          |
| Block3_conv1 (Conv2D) | (None, 56, 56, 256) | 294168     |
| Block3_conv2 (Conv2D) | (None, 56, 56, 256) | 590080     |
| Block3_conv3 (Conv2D) | (None, 56, 56, 256) | 590080     |
| Block3_Pool (MaxPooling2D) | (None, 28, 28, 256) | 0          |
| Block4_conv1 (Conv2D) | (None, 28, 28, 512) | 1180160    |
| Block4_conv2 (Conv2D) | (None, 28, 28, 512) | 2359808    |
| Block4_conv3 (Conv2D) | (None, 28, 28, 512) | 2359808    |
| Block4_Pool (MaxPooling2D) | (None, 14, 14, 512) | 0          |
| Block5_conv1 (Conv2D) | (None, 14, 14, 512) | 2359808    |
| Block5_conv2 (Conv2D) | (None, 14, 14, 512) | 2359808    |
| Block5_conv3 (Conv2D) | (None, 14, 14, 512) | 2359808    |
| Block5_Pool (MaxPooling2D) | (None, 7, 7, 512) | 0          |
| Average_Pooling2D     | (None, 1, 1, 512)   | 0          |
| Flatten               | (None, 512)         | 0          |
| Dense                 | (None, 64)          | 32832      |
| Dropout               | (None, 64)          | 0          |
| Dense_1               | (None, 2)           | 138        |

Subsequently, we divided the database set into 80% for training and 20% for testing. However, we initiated the
VGG-16 network with pre-formed weights on ImageNet leaving out the fully connected (FC) layer head (top layer).
We constituted a new fully connected layer head composed of pooling layers for addition to the VGG-16. The model
is compiled with the Adam optimizer and the learning rate of $1 \times 10^{-3}$ given the loss = binary cross-entropy since we
have 2 classes (1 or 0). Towards the end, we started the model for the learning process and we pass the whole database
through the data augmentation object (Table 1).

In order to facilitate the use of the platform, we have created a website [8]. The use of the open platform starts by
uploading the JSON model from our server which allows us to optimize the response time during the test. The test
takes place in a few steps which can be summarized in filling in the form and importing the image (figure 4). The
result is displayed in two forms; the first form via the website in a specific box, the second form via a PDF format
report (figure5).

The steps of use are as follow:
1) Select the radiology lab that performed the test.
2) Enter the patient’s information
3) Add a chest x-ray image.
4) Start the test (5 seconds only).
5) Display the results (on the web interface).
6) Generate a PDF document containing patient information and test results.

Fig. 3. Training Loss and Accuracy on COVID19

Fig. 4. Testing of our platform based on an image of a patient with COVID19
4. Conclusion

In this paper, we presented an intelligent and open platform to aid in the rapid detection of Covid-19. This platform uses chest X-ray images and the VGG16 architecture as a reliable model of artificial intelligence to provide a first test for Covid-19. The platform consists of three parts: The display of statistics in Morocco concerning confirmed cases, new cases, cured cases and deaths, awareness messages for the users of the platform (in our case the radiology laboratories) and the test platform. The user will manually insert the patient information and download the radio image and towards the end will start the test. The test will take 5 seconds and then a document will be generated containing all the information about the test and the X-ray image. We would like to point out that this platform is not yet validated by the official medical authorities.

References

[1] Zu, Z. Y., Jiang, M. D., Xu, P. P., Chen, W., Ni, Q. Q., Lu, G. M., & Zhang, L. J. (2020). Coronavirus disease 2019 (COVID-19): a perspective from China. Radiology, 200490.
[2] Pearson, C. A., Van Schalkwyk, C., Foss, A. M., O'Reilly, K. M., Pulliam, J. R., & CMMID COVID-19 working group. (2020). Projected early spread of COVID-19 in Africa. medRxiv.
[3] Gilbert, M., Pullano, G., Pinotti, F., Valdano, E., Poletto, C., Boëlle, P. Y., ... & Gutierrez, B. (2020). Preparedness and vulnerability of African countries against importations of COVID-19: a modelling study. The Lancet, 395(10227), 871-877.
[4] Narin, A., Kaya, C., & Pamuk, Z. (2020). Automatic detection of coronavirus disease (COVID-19) using X-ray images and deep convolutional neural networks. arXiv preprint arXiv:2003.10849.
[5] Hemdan, E. E. D., Shouman, M. A., & Karar, M. E. (2020). Covidx-net: A framework of deep learning classifiers to diagnose covid-19 in x-ray images. arXiv preprint arXiv:2003.11055.
[6] Gopalakrishnan, K., Khatian, S. K., Choudhary, A., & Agrawal, A. (2017). Deep Convolutional Neural Networks with transfer learning for computer vision-based data-driven pavement distress detection. Construction and Building Materials, 157, 322-330.
[7] https://github.com/ieee8023/covid-chestxray-dataset
[8] https://smartdeepemsi.com/