DarkCovidNet CNN for COVID-19 detection using X-Ray dataset images

At the beginning of the pandemic, Chinese clinical centers had insufficient test kits, which are also producing a high rate of false-negative results, so doctors are encouraged to make a diagnosis only based on clinical and chest CT results.

Academia tries to solve this by using CNN. So, a typical CNN structure has a convolution layer that extracts features from the input with the filters it applies, a pooling layer to reduce the size for computational performance, and a fully connected layer, which is a neural network.

The paper proposed uses a Darknet-19 model as starting point. Darknet-19 is the classifier model that forms the basis of a real-time object detection system named YOLO (You Only Look Once).

The result of this new combination is the DarkCovidNet. It basically has fewer layers and filters as compared to the original DarkNet architectures.

Which is the basis of the Darknet-19?

19 convolutional layers and five pooling layers, using Maxpool to downside the input by taking the maximum of a region determined by its filter. *These layers are typical CNN layers with different filter numbers, sizes, and stride values*.

The structure of the Darknet-19 can be represented as follows:

$$C_1\text{-}M_1\text{-}C_2\text{-}M_2\text{-}C_3\text{-}C_4\text{-}C_5\text{-}M_3\text{-}C_6\text{-}C_7\text{-}C_8\text{-}M_4\text{-}C_9\text{-}C_{10}\text{-}C_{11}\text{-}C_{12}\text{-}C_{13}\text{-}M_5\text{-}C_{14}\text{-}C_{15}\text{-}C_{16}\text{-}C_{17}\text{-}C_{18}\text{-}C_{19}$$

Where:

- C: convolutional layer.
- M: Maxpool layer.
- C_1: input layer.
- C_{19}: final output layer.

Thus, for input signal X (image) and kernel K, the 2D convolution operation can be defined as follows:

$$(X * K)(i,j) = \sum_m \sum_n K(m,n)\, X(i-m, j-n)$$

Where:

- $*$: represents the discrete convolution operation.
- K: matrix that slides over the input with stride parameter (m, n)

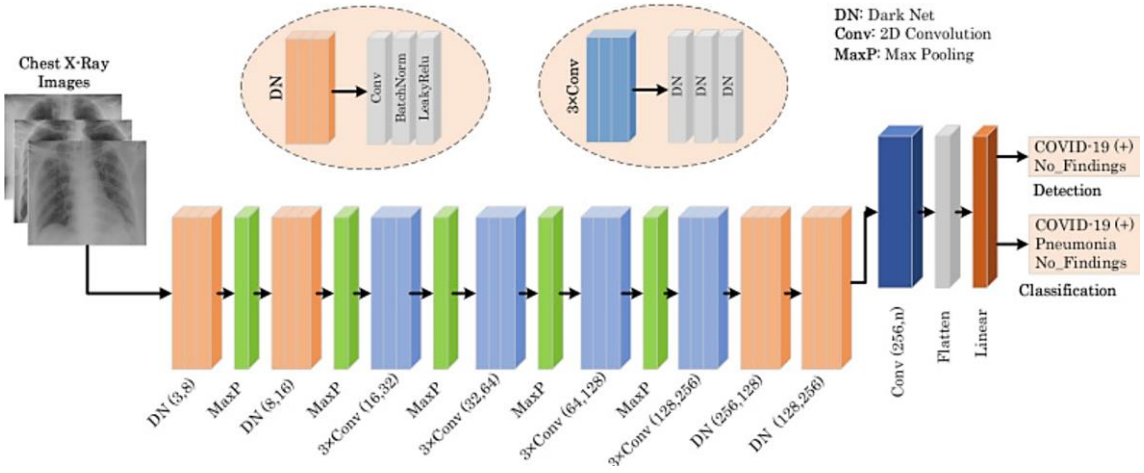
The main activation function in the Darknet-19 is the ***Leaky ReLu***, used to prevent the 'dying-back neurons' phenomena. Leaky Reu prevents this phenome by adding a small epsilon value to overcome the dying neuron problem.

Leaky ReLu, with $\varepsilon = 0.01$, is defined as follows:

$$f(x) = \begin{matrix} 0.01x & \text{for } x < 0 \\ x & \text{for } x \geq 0 \end{matrix}$$

The DarkNet-19 finish with the Avgpool and Softmax layers that produce the outputs.

The proposed DarkCovidNet model used in the study looks like:



It has only 17 convolution layers, in which each DarkNet layer has one convolutional layer followed by a BatchNorm and a LeakyRelu. Moreover, each 3x convolution layer (blue) appears an exactly sequence in the mid-term of the net.

The best performance will be obtained in a [binary COVID-19 detection task with DarkCovidNet]. However, could be useful also for a multi-class classification (like COVID-19, Pneumonia and No-Findings).

Relevant information:

- Type of inputs: