Artificial Intelligence Implemented in Covid-19 Detection

Kostandina Veljanovska*
* Department of Intelligent Systems, Faculty of ICT, University "St. Kliment Ohridski",
Bitola, North Macedonia
kostandinav@gmail.com

Abstract – Health professionals and scientists are at the forefront of the fight against the virus that humanity is currently battling. The next generation of scientists and physicians must be trained and prepared for a future pandemic, to respond to unexpected epidemics, and they must also learn to strengthen scientific communication. Scientists need to keep researching. Our attempt is in that direction to contribute to the study of a rapid way of diagnosing covid-19 that uses artificial intelligence. Namely, a machine learning algorithm for patterns recognition has been modeled in diagnosing the disease caused by covid-19 virus that uses a review of X-ray images.

Keywords - artificial neural network, covid-19, machine learning, deep learning, convolutional neural network

I. INTRODUCTION

The pandemic we have been facing for more than a year and a half is a widespread risk to humans and animals, and the effects are felt in everyday life, especially in the health and economic sector. Health professionals and scientists are at the forefront of the fight against the virus, together with people around the world managing the situation as best as they can. The scientific community is experiencing a negative impact from the outbreak of the virus, facing the closure of universities, research centers and laboratories, as well as the cancellation and postponement of some scientific events, professional conferences, symposia, workshops and training programs [1,2] . Universities, research centers and laboratories as a fertile ground for the development of new ideas and the promotion of advances in the science and the scientific community are in an inevitable situation. As scientists try to understand a new coronavirus and reduce the chaos it has caused, the epidemic has created chaos in science itself [2]. Reducing the number of scientific events and closing down scientific jobs will result in extended research time and, in some cases, will have to start again with full experiments, or put the experiments on hold, or reduce them at a minimum. The results of this will produce an economic burden on the researcher, eventually prompting psychological stress, anxiety, tension or depression, which will culminate in reduced scientific success [3].

Covid-19 is a viral disease caused by the SARS-CoV-2 virus that first appeared in the city of Wuhan, China, in December 2019, and then has spread around the world, leading to the declaration of a global pandemic. The virus has devastating effects on the lives of people around the world and to date it has infected over 226 million people. About 90% of them were cured, and 4.66 million people died, according to the Worldometers reference website. The general symptoms of the virus are: runny nose, sore throat, fever, cough, and headache. Some of the patients do not show strong symptoms of the virus, and some of them develop a severe form of the disease, especially combined with pneumonia of the lungs. Finding a way to quickly and accurately detect the disease is very important in order to reduce the negative effects of this disease and save human lives. Detection of coronavirus can be done in several ways: PCR - test, blood check and chest X-ray imaging. The first two are based on a simple comparison of numbers and reference values, but the third method requires more detailed consideration and analysis by experienced physicians. Our idea is to help in that direction and to develop a system that uses artificial intelligence (AI) to detect coronavirus in patients from radiographic images of their chest.

II. CORONAVIRUS DETECTION

Covid-19 is most commonly diagnosed with polymer chain reaction (PCR) and serological testing, for which there is a lack of necessary material and specialized personnel when performing these tests in regions and at a time when those regions are quite affected. In addition, PCR may have relatively low sensitivity. Therefore, alternative methods are needed to support the diagnosis of covid-19, such as noninvasive imaging. For example, computed tomography (CT) images can be used to detect certain manifestations in the lungs associated with covid-19, and in general, CT is a more accurate chest imaging technique and has a higher sensitivity and efficiency than X-rays of chest. However, the use of CT to detect covid-19 places a significant burden on diagnostic departments at times when they need to respond quickly to help minimize the risk of infection spreading. In fact, X-rays are part of routine screening of patients and remain the primary way to detect pneumonia due to shorter time and lower cost and, normally, lower radiation exposure compared to CT. Hence, our interest was directed in that area.

III. ARTIFICIAL INTELLIGENCE IN MEDICAL DIAGNOSTICS

A. General Applications

Artificial intelligence (AI) models are already yielding successful results in the analysis of medical data. In fact, new machines with artificial intelligence models have already been developed and work similarly to experts in specific diagnostic tasks. In addition, AI systems are adopted to extract information from medical imaging with the ultimate goal of creating tools to reduce diagnostic errors, improve efficiency, and reduce costs. These systems are typically embedded in image-based decision support systems to assist shooting professionals. Medical recording enables characteristic activities such as risk assessment, diagnosis, prognosis, detection of response to a particular therapy. Automatic processing requires less laboratory infrastructure and supplies, as well as fewer healthcare personnel. In this context, AI-based models that use medical X-rays as input are an alternative worth exploring for the automatic detection of covid-19 in patients for clinical analysis and diagnosis.

B. Artificial Intelligence in Coronavirus Detection

To study the impact and dynamics of the pandemic that is relevant to AI, various academic databases on clinical applications of machine learning and deep learning should be studied, including clinical features, electronic medical records, medical imaging (CT, X-ray, ultrasound images, etc.) to diagnose covid-19. This field has already being researched in scientific circles [5, 6]. Artificial intelligence techniques have been used to detect pneumonia by computed tomography of the lungs [7, 8]. Machine learning models have also been applied to covid-19 case data to predict infected cases and recovery rates using chest X-rays [9]. The k-NN model has been studied to distinguish imaging from a positive patient and imaging from a patient with another disease [10], or the AI model which, in addition to these two types of imaging, also includes imaging of healthy patients [11].

IV. MODEL DEVELOPMENT

For the purposes of this research, deep learning techniques as well as general machine learning techniques and algorithms were studied, and it was concluded that one of the most effective ways to analyze visual images when it comes to deep learning are convolutional neural networks (CNN). Experiments are already known for the diagnosis of coronavirus using CNN from CT scan [12, 13, 14] and from X-ray scan [15, 16, 17, 18, 19]. Analysis of the functioning of the database biases in the diagnosis of the virus is also part of scientific experiments with CNN [20]. Convolutional neural network has been applied on audio recordings of patients coughing to make an accurate diagnosis of covid-19 [21].

The artificial intelligence model includes machine learning (ML) and deep learning (DL) in order to automatically detect significant patterns in data and solve problems that are impossible (or impractical) to represent and solve with conventional algorithms [22, 23]. Deep Learning (DL) learns high-level abstractions in data using hierarchical architectures. It combines several layers of nodes to build a gradually more abstract representation of the data, allowing concepts such as categorization or classification of objects to be learned directly from raw data collected by onsite-mounted sensors. The current success of DL is directly related to the production of inexpensive graphics cards with multiple processors or graphics processing units that increase speed and reduce training time to create a deep learning model. Convolutional neural networks (CNN) are used to recognize shapes / forms / patterns and are the dominant DL architecture for image classification that may even compete with the human ability to perform recognition and classification tasks.

A. Artificial Neural Network – Convolutional Neural Network

CNN brought a revolution in the field of computer vision by increasing the accuracy of image classification, but also many times improved scene classification, object detection, semantic segmentation of biological images and face detection, text recognition and human body recognition in natural images. The main practical success of CNN is the face recognition and automatic driving of cars.

The CNN uses hierarchical layers of convolutional filters to mimic the effects of sensory fields in the visual cortex of animals, taking advantage of the local spatial correlations present in the images [22]. The CNN-based model generally requires a large set of training samples to achieve good generalization skills.

Convolutional neural networks as one of the most powerful deep learning algorithms designed for image processing contain three types of layers (levels): convolutional, pooling layers and fully connected layers.

CNN is a multilayer perceptron that uses a bit of pre-processing unlike other image classification algorithms. The network learns to optimize filters through automatic learning as opposed to conventional algorithms where such filters are manually designed. This means that CNNs have a key advantage because they are independent of prior knowledge and manual property extraction. They use convolution in at least one network level instead of general matrix multiplication [24].

The following figure (Figure 1.) shows an example of a convolutional calculation where a block of pixels through a filter generates a map of properties, i.e. an image that will be used for further processing.

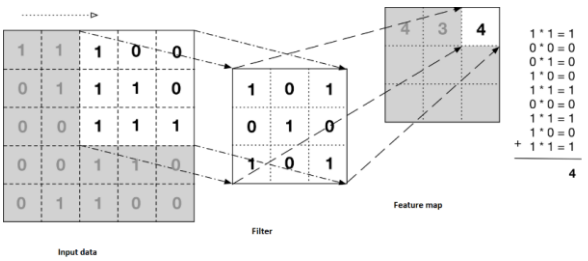

Figure 1. Method of convolutional calculation

The convolutional layer contains a set of filters and their parameters have to be learned. Every individual filter is convolved with the input data to calculate an activation map which is made of neurons. Normally, the height and weight of the filters are smaller compared to the same of the input volume.

The way convolutional calculation transforms size of data, we can see in following calculation. If the size of the image is N x N and the size of the filter is F x F, then after convolution the result will be matrix with dimension:

(N x N) convolve (F x F) = (N-F+1) x (N-F+1)

Each step at the convolution level is followed by a non-linear activation function.

The output from the convolutional layer contains high-level features extracted from the data. A fully-connected layer in order to learn non-linear combinations of these features is added after cycles of convolution and reduction of the size of data features.

Pooling layer is usually used to reduce the spatial volume of input images after convolution. It is used between two convolutional layers. The max pooling or average pooling or L2-norm pooling is used in order to reduce the spatial volume of the input image.

At the end, a fully connected layer which involves weights, biases, and neurons connects neurons from one layer to neurons in another layer. It is used to classify images between different categories as process of training the network goes on.

B. Covid-19 Detection Algorithm

For the purposes of this study, we developed a model that, based on collected X-ray images of the chest, recognizes positive and negative patients on covid-19, that is, images of patients who tested positive for PCR and patients who tested negative for coronavirus or patients without any diseases. A set of chest X-ray images of people that have been processed and divided into two sub-sets for training and testing is used as an input database. The data were taken from a database available online and were properly prepared for processing and designing the model. We used Keras library. The experiments were performed in two phases: training of the model in 10 epochs as the first phase and second phase, training in 20 epochs. In both phases, almost 90% of the data were used (224 images) for training and 12% for testing.

V. DISCUSSION OF THE RESULTS

Our model contains four convolutional levels. The first level accepts pictures and does filtration and activation. The next level is pooling level where the pictures are processed and divided into blocks. Over-fitting of the model is avoided using dropout of certain percentage of data. The last level of the network uses only one dimensional data, so three dimensional data are flattened with specific function.

Database has 224 images for model training. As the process of training was going on, it was evident that the model was improving in terms of increasing the accuracy and lowering the loss in predicting the result of diagnosis for patients. Still, there were epochs where the model entered in over-fitting, stagnating the process of increasing the accuracy of prediction.

As it can be seen from Table I., in the first phase, the maximum result that is reached in the 10th epoch is 95.982% classification accuracy.

It was noticed that after testing the model with 30 images, four mistakes were done, i.e. four images that are from positive covid-19 patients, the model classified them as normal.

TABLE I. TRAINING PROCES FOR THE FIRST PHASE

N. of Epoch	***Discussion of the training process***	***Accuracy (%)***
1	Trained after 7 iterations	56
2	Trained after 6 iterations	64
3	The accuracy increased, loss decreased	73
4	Loss decreased	85
5	The accuracy increased, loss decreased	91
6	Model stoped increasing accuracy (overfitting)	90
7	Slightly increased accuracy	94
8	Due to the size of the database, overfitting	93
9	The loss increased, and the accuracy is lower than in 7th epoch	93
10	Model reached maximum accuracy	96

During the second phase we noticed that the model does over-fitting again, due to the size of the database, reaching a maximum percentage of accuracy of 98.25%, which is not enough.

The maximum result was reached at the 20th epoch of 98.25% accuracy. Table II. shows the whole process of training. There were epochs where the model is over-fitting, after 10th, 13th and after 17th epoch. Our supposition is that it was due to the database size. Still, if the database size is big enough, dropout could improve the situation. But, at this time due to difficulties in functioning in hospitals and radiographic departments it was impossible to gather database that has proper size in order to make this research more accurate.

For the second phase after testing the model with 30 images, it made two mistakes, i.e. two images that are from patients negative on covid-19 model predicted as positive on covid-19. It can be seen that the model after 20 epoch training corrects the error of the model that was trained in 10 epochs. It was noticed that the model in the learning process starts with about 50% accuracy and 1.2% loss. After that as the training process continued and as the weights were adjusted the accuracy increased and the loss decreased.

TABLE II. TRAINING PROCESS FOR THE SECOND PHASE

N. of Epoch	*Accuracy (%)*
1	50
2	71
3	76
4	85
5	87
6	90
7	92
8	93
9	94
10	92
11	93
12	94
13	93
14	95
15	96
16	97
17	95
18	97
19	98
20	98

VI. CONCLUSIONS AND FURTHER RESEARCH

In the hope that the world will continue to learn more about covid-19 and control the virus effectively, we need to continue to research, and re-examine and only then will science advance again and the scientific community function normally again.

This research was conducted in order to help health professionals to effectively, accurately and fast detect each single positive case on covid-19 using X-ray images. The method that we propose is convolutional neural network as the most effective deep learning technique for machine learning visual patterns recognition. Network was trained on a small database of X-ray images. We can conclude that after training the model with 20 epochs, we got a maximum accuracy of 98 percentage which means that the model has a high degree of accuracy. Nevertheless, further upgrades and increases in the collection of recordings are needed for future training and testing. By applying a larger database, and additional tools and libraries the model training process will improve and testing will show better results. After that the well-designed model could be implemented to use in a real situation.

Combining the model of convolutional neural network for covid-19 detection from X-ray images of the patients with other data gathered from the medical record of the patients, such as coughing for example, could be one of future steps in our research that will improve the precision and speed up the process of establishing the diagnosis for the patients and simplify the procedures for the medical staff.

Implementing another technique from artificial intelligence combined with convolutional neural network could speed up the process of recovering for the patients and save lives, at the same time, save money, save time and save energy for paying attention to other diseases and patients. We have started analysis of this issues and that will be focus on our future research.

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