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Use of Regressive Artificial Intelligence and Machine Learning Methods in Modelling of COVID-19 Spread (COVIDAi): Project Review

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Abstract: In this paper, a review of the project Use of Regressive Artificial Intelligence and Machine Learning Methods in Modelling of COVID-19 Spread (COVIDAi) is presented. The main goal of the project is to design two main AI-based models: epidemiological and personalized. After the introduction, a brief description of project partners and activities is provided. Furthermore, a brief description of the two main project activities is provided. After the description of the aforementioned project activities, a review of scientific papers published during project execution is presented.

Keywords: Artificial intelligence, COVID-19, Epidemiological models, Machine learning, Personalized models

1. Introduction

COVID-19, colloquially coronavirus, is a severe respiratory disease caused by SARS-CoV2 virus [1]. In March 2020, The World Health Organization (WHO) announced the pandemic [2]. Ever since, the world is, in some form, under the restrictive measures used to interrupt the spread of COVID-19 infection. In the early days of the pandemic, the main goal was to predict the spread of the infection in order to minimize the number of infected individuals, and consequently the number of deceased patients [3]. Along with the outbreak of the pandemic, especially in the second wave in late 2020, the need to develop more effective methods for the treatment and care of COVID-19 patients increased [4]. Such a condition is a direct consequence of the far-reaching spread of the infection and its growing impact on the healthcare system [5].

Artificial intelligence (AI) and machine learning (ML) are today widely integrated into the medical profession, with a wide range of applications [6, 7]. Following the described trends, a team composed of scientists from the University of Kragujevac (Serbia) and the University of Rijeka (Croatia) launched the COVIDAi project, with the aim of applying AI and ML methods in the fight against the COVID-19 pandemic. This conference paper aims to briefly describe the activities carried out within the COVIDAi project and give a brief overview of the results and findings.

2. A brief description of project activities and partners

COVIDAi project is a project supported by Central European Initiative (CEI) under the grant number 305.6019-20. The project consortium consists of University of Kragujevac, University of Rijeka, Faculty of Engineering, and Clinical Hospital Center Rijeka. The main researchers of the project are Professor Nenad Filipović (PI) from the University of Kragujevac and Professor Zlatan Car (CO-PI) from University of Rijeka, Faculty of Engineering. All project activities are performed in order of

creating a tool that will be used in medical practice. Main activities performed within the COVIDAI project include the development of two models:

- Personalized AI model for COVID-19 prediction (monitoring of patient's condition and prediction of disease progression in time)
- An epidemiological model for COVID-19 (monitoring of number of people susceptible/exposed/infected/dead/recovered from COVID-19)

COVIDAi tool would help medical experts to decide whether the patient will be subjected to further analysis and prescribe adequate therapy. Predictive models based on machine learning can provide useful data in terms of prediction of epidemiological events, which can save time for the timely and optimal response of both the health system and the society.

3. Epidemiological models for COVID-19

COVIDAi uses a compartmental epidemiological model, based on the partial differential equations to describe the spread and clinical progression of COVID-19. The basic model structure is inspired by several studies on the natural clinical progression of COVID-19 infection. Alongside models based on differential equations, models based on the utilization of AI and ML algorithms were also developed. The most prominent results were achieved by using a multilayer perceptron (MLP) and genetic programming (GP). Prediction of COVID-19 spread with COVIDAi tool is performed by using data provided by institutions such as WHO, Johns Hopkins University or Institutes of Public Health, as presented in Figure 1.

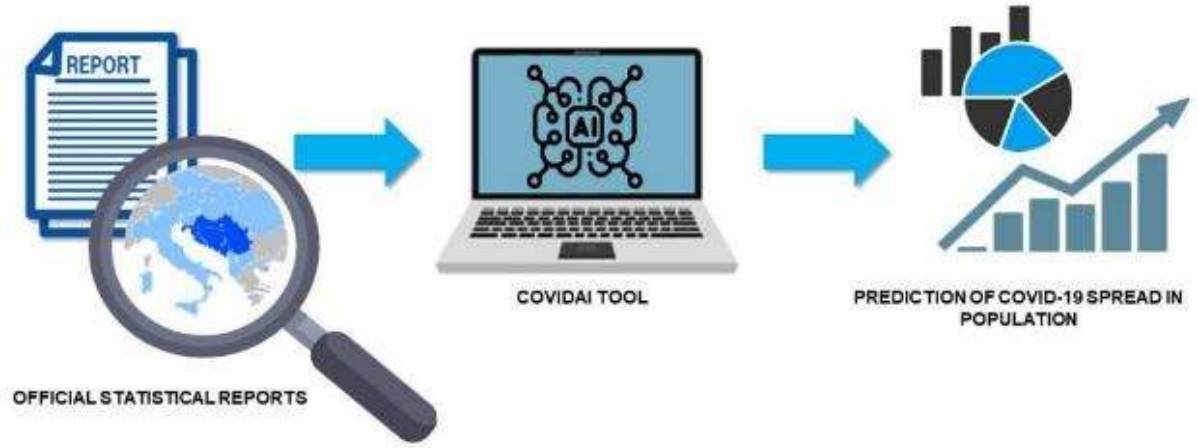

Figure 1. *A flowchart of COVID-19 spread prediction using COVIDAi tool*

Alongside the epidemiological aspect [8], modeling of COVID-19 spread can also be used in forecasting the stock market dynamics [9].

4. Personalized AI model for COVID-19 prediction

The developed disease progression tool uses machine learning methods to mine heterogeneous patient data provided by Clinical Centers in Rijeka, Croatia, and Kragujevac, Serbia. The main aim of this tool is to assess the disease progression of the patient infected with COVID-19 in the next couple of days. In order to estimate the disease progression, the input dataset consisting of:

- demographic data,
- clinical image,
- blood test data and

- imaging data

is used. The result of the model is a prediction of the category risk of mortality.

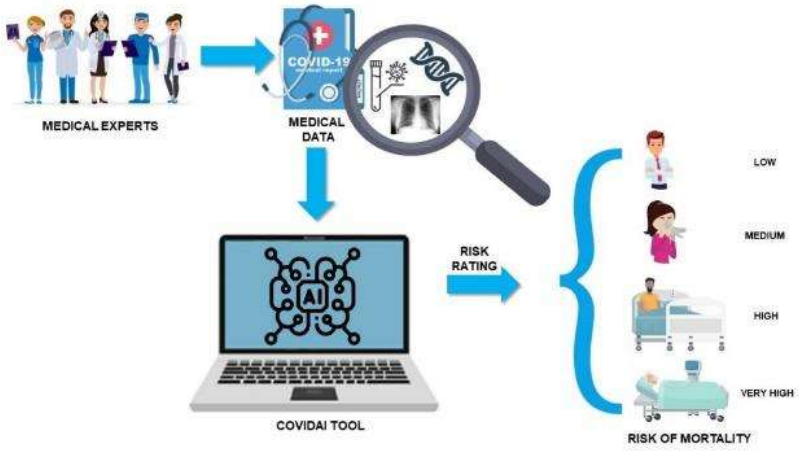

Figure 2. *A Flowchart for mortality risk estimation using personalized COVIDAi tool*

A unique feature of COVID-19 interstitial pneumonia is an abrupt progression to respiratory failure. Patient-specific lung models developed during COVIDAi project are focusing on the spread of virus-laden to many regions of the lungs from the initial site of infection. An example of such a model is presented in Figure 3.

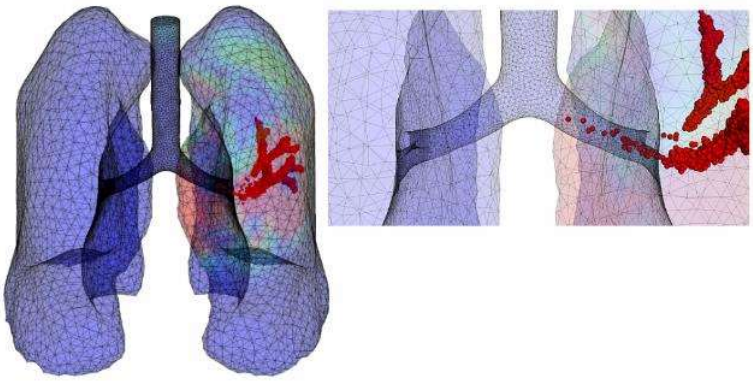

Figure 3. *An example of patient-specific lung model*

5. Achieved results

The results of the project have been published in several scientific articles in eminent journals. The first research published during the project is an article by Anđelić et. al. [10]. The aim of the research presented in this article was to implement genetic programming algorithm (GP) in order to model the spread of COVID-19 in China, Italy, Spain, and the USA. The modeling process is based on the estimation of epidemic curves derived from the number of infected, deceased and recovered patients. Alongside individual country models, the global model was developed as well. From the results, it can be seen that models for the number of infected and deceased cases achieved the R^2 scores of 0.999, while the models for the estimation of the number of recovered patients achieved the R2 scores of 0.998.

Another similar research was also published during the project. The research presented in [11] was based on the utilization of GP for estimation of COVID-19 epidemic curves for the USA, for each state

individually. On the described way, R^2 scores in ranges 0.9406–0.9992, 0.9404–0.9998 and 0.9797–0.99955 were achieved for the estimations of infected, deceased and recovered patients respectively.

An overview of AI-based epidemiological models was presented in [12], where a detailed systematic review was given.

Alongside epidemiological models, another goal of the project was to develop automatic, personalized, models that will be used in the treatment of COVID-19 patients. The aforementioned models are used in order to develop an automatic decision support system that will be used in clinical practice as help to medical professionals. In the research published in [13] a system for the automatic evaluation of the lung condition of COVID-19 patients was presented. The aim of this research was to estimate the clinical picture of the patient from the x-ray images of the lungs. During the research, multiple convolutional neural networks (CNN) were used, and these are:

- AlexNet,
- VGG-16,
- ResNet50,
- ResNet101 and
- ResNet152.

Results show that the best classification performances can be achieved with ResNet152. By using this CNN, micro-AUC and macro-AUC values up to 0.94 were achieved.

Another research, based on the prognosis of disease development, is presented in [14]. In this research, a personalized model for COVID-19 disease prognosis is presented. The model is based on the combination of machine learning and finite element simulation. By using the presented approach, prediction accuracy up to 90% was achieved.

6. Conclusion

In the presented project review main activities conducted during the project duration were presented. For each activity and model developed a brief description was provided. In addition to the description of the activities, a brief description of the publications published as part of the project is given.

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