Web Application for Statistical Tracking and Predicting the Evolution of Active Cases with the Novel Coronavirus (SARS-CoV-2)

Iulia Clitan, Adela Puscasiu, Vlad Muresan, Mihaela Ligia Unguresan, and Mihail Abrudean

Abstract—Since February 2020, when the first case of infection with SARS COV-2 virus appeared in Romania, the evolution of COVID-19 pandemic continues to have an ascending allure, reaching in September 2020 a second wave of infections as expected. In order to understand the evolution and spread of this disease over time and space, more and more research is focused on obtaining mathematical models that are able to predict the evolution of active cases based on different scenarios and taking into account the numerous inputs that influence the spread of this infection. This paper presents a web responsive application that allows the end user to analyze the evolution of the pandemic in Romania, graphically, and that incorporates, unlike other COVID-19 statistical applications, a prediction of active cases evolution. The prediction is based on a neural network mathematical model, described from the architectural point of view.

Index Terms—Coronavirus infection, web responsive application, COVID-19 statistics, prediction model, neural networks.

I. INTRODUCTION

First cases of COVID-19 on the Romanian territory were confirmed on 26 February 2020. In 19 March there were already 277 cases reported by the authorities. The first case of COVID-19 pandemic, originated from the city of Wuhan of China in December 2019 and since then it spread and the coronavirus outbreak evolved into a pandemic [1], declared in 11 March 2020 by the WHO (Word Health Organization).

The COVID-19 pandemic has highly affected the health, socio-economic and financial matters of the different countries of the world [2].

Since then, local authorities took a bunch of restrictive actions to prevent the spread of COVID-19 (corona virus disease caused by SARS-CoV 2) (severe acute respiratory syndrome coronavirus 2). From 16 March to 14 May there was a national lockdown, that decreased the number of active cases in our country, thus on 15 May 2020 the President of Romania promulgated the law on the establishment of the state of alert on the territory of Romania, a state that is

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maintained since then.

However, as can be observed from analyzing the red line in Fig. 1, the number of cases reported each day as COVID-19 positive, continue to have an ascending allure, reaching in September 2020 a much higher infection rate than at the beginning of the pandemic. In Fig. 1, the red line corresponds to the number of new cases reported every day, the green line represents the number of cured cases each day while the black line denoted the number of reported daily deaths due to infection.

In order to understand the evolution of this disease over time and space, more and more research is focused on obtaining prediction models [2]-[4]. Such models could help primarily the authorities to manage and content the spread of COVID-19, since they could test and observe the effect of different actions, or restrictions that can be imposed in order to decrease the number of active cases in their country. Having a prediction model, could mean that different scenarios or practices can be carried out in simulation and thus the scenario that proves to have the best outcome can be selected and implemented. The aim being to limit the intra-community spread, thus reducing the pressure put on the health care department [5]. The fewer the cases reported every day (smaller number of diseases), means more time and resources allocated to threat the most vulnerable and the most severe cases of corona virus disease [6], [7]. Even more, decreasing the number of cases and limiting the spread, means that the health care system is not overwhelmed and can threat all active cases of COVID-19, regardless of the severity.
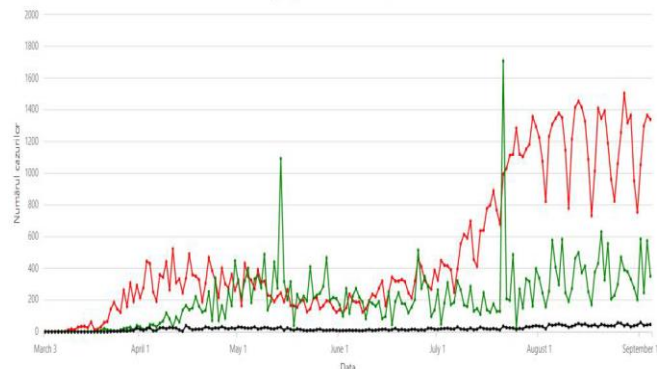

Fig. 1. The general evolution of COVID-19 cases in Romania (Red line - daily cases of infections; Green line – daily number of cured cases) March - September 2020.

The aim of this paper is to present a web application, design in order to show statistical information on the reported active cases in our country, based on the official reported and

collected data, and to incorporate a prediction area to ours application based on the data predicted by a neural networks mathematical model. The current research focuses on presenting some development aspects of the developed application, and to describe the architecture that the mathematical model is based on.

II. WEB APPLICATION FOR TRACKING THE EVOLUTION OF COVID-19 CASES IN ROMANIA

The developed application must be web responsive so that it is as pleasing to the eye as possible, regardless of the viewing environment or the resolution of the used device. We want the application to be easy to follow, and for each user to quickly find the information they are interested in.

Most of the presented information is in the form of diagrams for ease of analysis and perception of data, which is easier to assimilate than in the case of tables (that would be very large for this type of application/data). In order not to have a monotony of the application, the daily information displayed on the country map is also used, for a spatial distribution, and the main data are given by counties, represented with colors of different intensity depending on the severity.

Currently, there are some web applications like the one we made, but they are only informative about the situation of the spread of COVID-19 disease. The novelty introduced by the developed web application is the part dedicated to predicting the evolution of the number of cases. Datelazi.ro is a pro-bono project developed by Code for Romania that presents the data provided by the Romanian Government in a graphic form that can be easily traversed. Graphs.ro is a personal project, made by Dragoş Vână. The data is collected from the Romanian Ministry of Health and can be accessed in the form of a json, provided the source is credited. Covid19.geo-spatial.org, is an application that has a team of about 32 volunteers, so the data are quite numerous and complex. The collected data can be accessed using a dedicated API (Application Programming Interface) and can be found in json format.

A. Application Design and Implementation

Fig. 2 shows the use cases diagram of any client, which uses the application developed by the authors. No authentication is required to access all the information available in the interface. One can note from this diagram the main structure of the web application, as well as the arrangement of the information.

The aspects related to the implementation of the application will be presented in the following.

To create the desired application the authors used on the front end and stylization: Razor, Bootstrap, HTML and CSS. For the implementation of the application back-end part, the server and its connection to the database were made, the language used was C#. The authors also worked with Dapper, Syncfusion.Blazor, System.Json, System.Data.SqlClient packages.

Net is an open source platform developed by Microsoft, with which one can build applications for desktop, web, mobile, IoT and games. They can be written in F#, C# or Visual Basic, but no matter what language is used, the code

runs natively on any compatible operating system [8]. Blazor is a free and open-source framework used in creating interactive web applications, which uses C# instead of JavaScript. It uses open web standards without plugins. The code running in the browser runs in the same security sandbox as the one used by the JavaScript framework. Blazor applications are based on components, which are elements of the user interface [9].
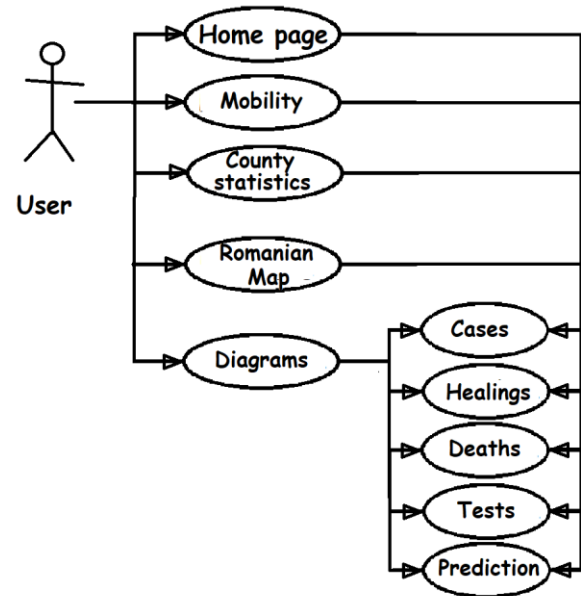

Fig. 2. The diagram of use cases.

The MainLayout of our application is the basic one of all Razor components, here all the pages and the navigation menu are inserted. Its use is efficient since there is no need to insert the navigation menu part into each page.

Syncfusion.Blazor is a library that offers a multitude of UI (User Interface) components for Blazor applications, having a high performance and being able to work with a large volume of data. This library was chosen to create all the diagrams in the project, and for creating the country map. Diagrams are the best way to visualize information since they can be compared more easily with each other, and we used their layout over time since we want to emphasize the evolution and development of cases (tendency to increase or decrease). Both the diagrams and the map have different labels added, for better and more aesthetic interaction.

Both relational and non-relational databases were used in this project, combining them for the best possible data management. Because some data had a very large volume of information and manipulation could be done very easily using the non-relational database, and others had a small volume at the beginning and were much easier to manipulate and organize with the help of the relational database. Adding data to the database is done automatically, thus no administrator role is needed.

To populate the relational database with the current values, a request is used to the file available on graphs.ro, it is saved locally in a json file, and then its deserialization is performed. The actual insertion in the database is done automatically when the application is run, depending on the time of day when it is run and depending on when the last update was made (reporting data for the last 24 hours is done daily at the

same time). The non-relational database used was of the json document type. It was used to implement the map type statistical view since it requires a very large volume of data and was an easier way to manage.

B. The Web Responsive Application Interface

Since the current application is developed for the statistical analysis of COVID-19 evolution in Romania, the text on many pages is in Romanian language. The first time the application is run, the browser opens with the Home Page where one can see all the functionalities that the customer has available. This page also contains data about the latest updates and a small preview for the data that can be found in the application, as shown in Fig. 3 [10].

The Mobility page has a built-in graph from the Graphs.ro page, regarding Google's mobility in Romania as a percentage. An interesting aspect is that it is very easy to see the moments when measures have been taken to relax the restrictions in the country (see Fig. 4).

The Romanian Map page, as can be seen in fig. 5, presents statistics for the current day for each county of Romania. The user being able to select the data set according to which to stain the map.

In the County Statistics page (Fig. 6) one can view for each county a diagram with the statistics of new cases over the last 7 days, or if one of the counties is selected it redirects the user to the page of the respective county.
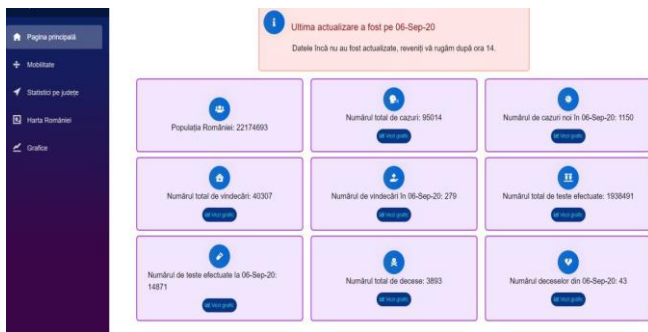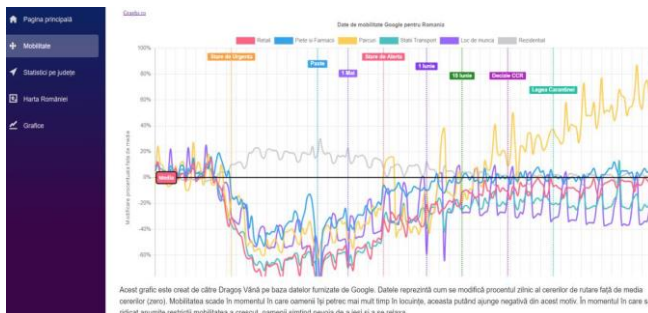

Fig. 3. The home page.
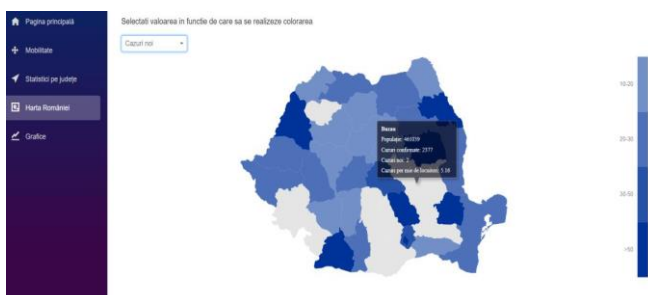

Fig. 4. The mobility page.

Fig. 5. The Romanian Map page.

Fig. 6. The county statistics page.

When one clicks on the menu on Diagrams, a dropdown submenu opens (as shown in Fig. 2 diagram), and on the Diagrams page two graphics are displayed over time (from March 2020 to present). The first graph shows the daily number of new cases, healings (cured cases) and deaths, and the second illustrates the statistics for active cases in Romania.

If we enter the submenu at Tests, an important statistic will be graphically accessible on the Tests page as depicted in Fig. 7, which is somewhat avoided when presenting official data: the number of daily tests performed nationally. If we were presented with this data, we could more easily understand what percentage of the number of tests performed, came out positive.

The Prediction page is under development, since it must be linked with the prediction model described further, and it must incorporate a menu for selecting different scenarios (that influence the input signals for the prediction model). However, an example of a predicted scenario diagram, that shows the evolution of COVID-19 cases, is given in Fig. 8.

III. COVID-19 PREDICTION MODEL

The elaboration of a prediction mathematical model [11] represents a task of high difficulty due to the high complexity of the virus transmission dynamics.
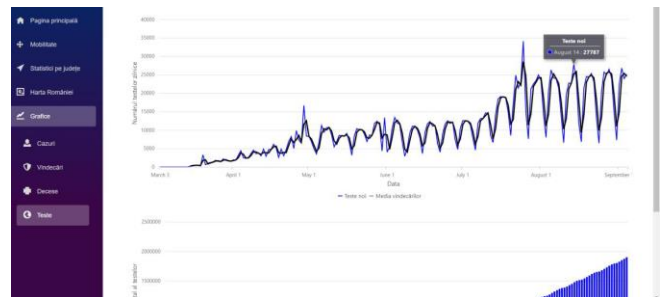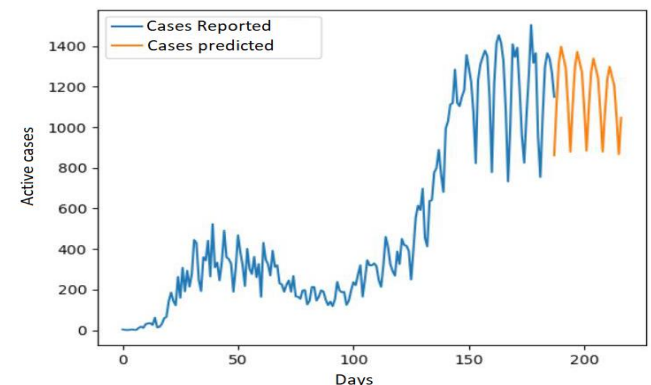

Fig. 7. The diagrams/tests page.

Fig. 8 An example of the prediction of active cases per day.

The process of virus transmission is a biological process which has the particularities of having large number of input and output signals, respectively the input-output interdependencies being strong nonlinear ones. Consequently, this process is a strong nonlinear MIMO (Multiple Input Multiple Output) process.

The identification of this type of processes is based on processing of large databases containing information about past cases. In this context, the usage of neural networks represents an opportunity. In order to prove the neural networks capacity of learning the behavior of complicated mathematical functions with applications in COVID-19 problem, the case of the signal from Fig. 9 is considered. In Fig. 9, the variation of the new daily cases of infections with SARS-CoV-2 virus, on the territory of Romania, is presented. The considered time interval is from 15 February 2020 to 28 October 2020, more exactly covering 257 days of the pandemic. The source of the input data, graphically presented in Fig. 9, is the https://www.worldometers.info/coronavirus/ web page.

From Figure 9, the strong variation of the considered signal is highlighted due to the consistent variation of the infection's cases from a day to the next one and due to the consistent variation of COVID-19 performed tests during the weeks and during the weekends.

In order to learn the behavior of the signal considered as an example in Fig. 9, a fully feed-forward neural network, having many hidden layers of significant high sizes, is used. After training the neural network and simulating it, the comparative graph between the experimental curve from Fig. 9 and the response of the solution generated by the neural network is presented in Fig. 10. The high accuracy of the obtained neural model results both directly from Fig. 10, the two responses being almost superposed, and through the insignificant value of the quality indicator (the considered quality indicator is MSE (Mean Square Error) and by computing its value, considering 257 pairs of samples of the two curves presented in Fig. 10, the value of 5.9028 cases results). These aspects prove the viability of using neural networks in modelling the virus transmission dynamics. This remark is, also, strengthened by the fact that neural networks have a parallel structure [12], aspect which allows them to process large number of data.

The general architecture of the proposed prediction model for the virus transmission dynamics is presented in Fig.11.
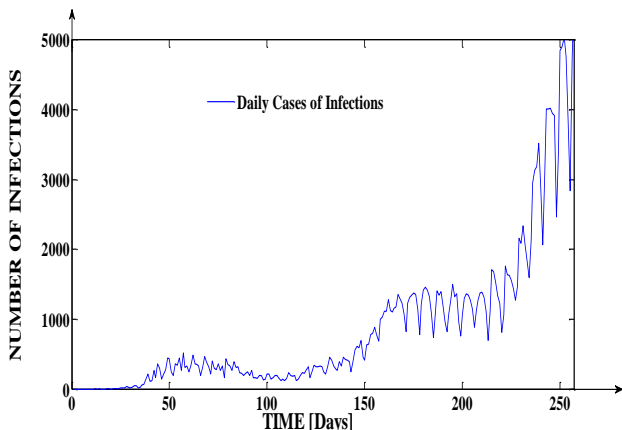

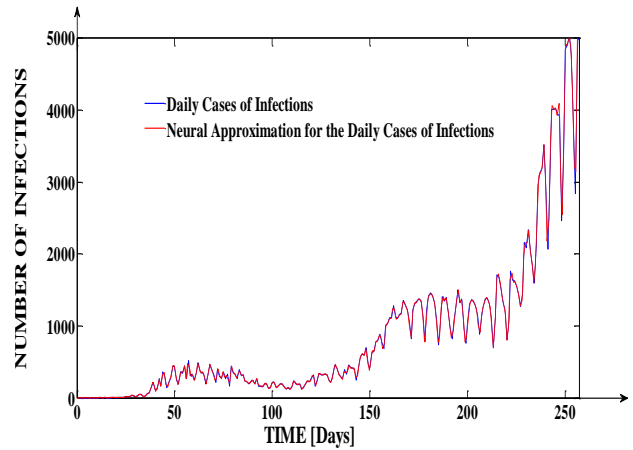Fig. 9. Daily cases of infections in Romania according to Worldmeters COVID-19.

Fig. 10. Comparative graph between the curve from Fig. 9 and response of the neural network used for its approximation.
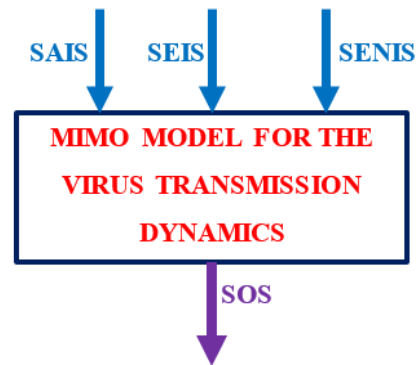

Fig. 11. The proposed architecture of the prediction MIMO model for the virus transmission dynamics.

As it is highlighted in Fig. 11, the future proposed model for the virus transmission dynamics will be a MIMO type one. Also, it will be implemented using neural structures which will contain different types of neural networks, depending of the types of the input-output dependences associated to the model. The main sets of the model input signals are: SAIS – Set of Active Input Signals (for example the treatment procedures or the legislation in the domain of the COVID-19 problem; SEIS – Set of Exogenous Input Signals (for example the climatic conditions); SENIS – Set of Endogenous Input Signals (for example the approach of the pandemic by the population). The proposed model will provide the prediction of the SOS (Set of Output Signals) as for example: the future daily cases of infections; the future daily active cases; the future number of cures.

As the main future research activity and direction, we will approach the problem of determining the prediction model for the virus transmission, based on large sets of different types of data, containing information about past cases.

IV. CONCLUSION

The aim of the research carried out by the authors is to develop a statistical web application, with prediction of new active cases of coronavirus disease (COVID-19) integrated. The first step is to develop a statistical web application that is tracking the evolution of coronavirus disease pandemic, using graphical representation, since it is more easily to interpret large amount of data this way, to emphasize the current situation. The web responsive application described

in this paper is in the early stages of implementation. Others can be added to the presented functionalities. A more detailed development of this application will be made on the part regarding the evolution prediction of COVID-19 cases.

The main step is to implement a mathematical model using neural networks to predict the pandemic evolution on Romanian territory based on different scenarios, thus giving for example the local authorities a tool of analyzing how different measures and actions to prevent the further speared of this virus work, and act accordingly.

The research team from which the authors take part, too, works hardly, in present, to obtain a functional prediction model, based on multiple and consistent data, containing information about past cases.

As future research, the model and the web application can be extended to predict the evolution of active cases at European level. For further development the authors will also add an option to change the language of the displayed text.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

I. Clitan performed the state of the art and described the web responsive application on COVID-19 evolution. A. Puscasiu elaborated the web responsive application. V. Muresan developed the prediction model's architecture. M. Unguresan contributed in analyzing and processing the experimental data. M. Abrudean proofread the paper and contributed to the development of the prediction model.

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