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Forecasting and Decision Making in the Context of COVID

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Abstract*: The results of a literature review on the topic forecasting and decision making in the context of COVID are presented. The aim of the paper is to analyze the statements and research results of various experts on COVID modeling and the implementation of a systems approach concept for the selection of a combination of models, hardware and software. Modification of modeling, prediction methods to control the emergence, development and elimination of the consequences of the "so-called pandemic" COVID. For the problem at hand a comprehensive solution of the COVID monitoring problem can be proposed which has a combination of different modeling techniques. We also provide specific data from the analysis based on wavelet coherence. These results are presented in the form of charts that help to understand some predictive estimates, be useful for future research, and confirm some data.*

Keywords—forecasting; decision making; COVID; algorithm; memory-based reasoning; intelligent data analysis; wavelet coherence

1. INTRODUCTION

At the end of 2019, a novel coronavirus now known as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was identified as the cause of a cluster of pneumonia cases in Wuhan, a city in the Hubei Province of China. It rapidly spread, resulting in a global pandemic. In February 2020, the World Health Organization named the disease COVID-19, which stands for coronavirus disease 2019 [1].

To the current state of coronavirus disease in the world, humanity did not come by accident but because of the gradual development and spread of acute respiratory disease (ARI). Gradually from ARI to various variants of influenza, from pneumonia to atypical pneumonia and so on. Gradually viruses have mutated (and continue to mutate) and vaccines or vaccines have not had the desired effect on a wide range of mutated viruses.

The need for risk management in COVID conditions is caused by global and national factors which have a negative impact on human security. The COVID-19 pandemic has become a global challenge that has engulfed almost all of humanity and has affected various areas of its life [2]-[7]. This necessitated the conduct of relevant research, which increased interest in this topic and contributed to the emergence of many works. Ultimately, this determines the scientific and practical interest of this direction, its relevance and significance.

The life-safety management process should include COVID modeling to identify risk factors, risk assessment at all stages of information acquisition, transformation, processing and display system development, and development of a decision-making subsystem to manage the risk from COVID. This makes it necessary to use a wide range of analysis methods that have proven themselves in various fields of research [8]-[17].

COVID modeling to identify risk factors includes investigation of sources of hazards (threats), pandemic triggering events, description of the facility and existing protective equipment, possible scenarios of the course of events and their ranking. This approach helps to conduct experimental studies without the threat of life and the development of negative phenomena. Moreover, it becomes possible to make informed decisions that are aimed at preventing certain threats. This helps to effectively use the available resources, to predict the development of the situation.

Forecasting is a science-based assessment of the future states of the object of interest. Forecasting should show when and in what sequence the COVID states will change and how the COVID state will affect various risks. Thus, we can evaluate the decisions made and analyze their effectiveness. If necessary, we can build a new model, correct the decisions made.

Thus, the main goal of this article is to review a number of works devoted to the study of the COVID-19 pandemic, their generalization and analysis, where special attention is paid to mathematical methods of forecasting. But first, we will consider the pandemic as the object of study of many researches.

2. THE COVID-19 PANDEMIC AS AN OBJECT OF STUDY

Given the worldwide relevance of the stated topic, we have a significant number of publications that focus on "pandemic coronavirus disease 2019 (COVID-19)" [1]. Nevertheless, to analyze the available information, it is not enough to read and list a large number of sources. Here we encounter such problems as:

1. Lack of a counter-coveted government situation room with specialists in various fields and with credible and versatile assessments of the COVID situation.

2. Lack of a clear division of management, at times to the detriment of other diseases.

3. Uncertainty and incompleteness of baseline data for the problem at hand.

4. Lack of uniform criteria for judging the proposed material (reducing data to similar or close COVID scores).

5. Independence of these data from commercial interests (e.g. interests of phamacological corporations for extra profit).

6. Influence of political interests on the results of the analysis.

7. Difficulties with forming competent expert groups to evaluate the situation and develop effective management solutions to eliminate the consequences of the so-called "pandemic".

Based on this, we present several studies where COVID-19 is considered as an object of study.

B. M. Batubara analyzes the global problems in the field of education that are associated with the development of the Covid-19 pandemic [18]. The paper examines the problems of education in Indonesia. The actions of the government, which are aimed at supporting the educational process in a pandemic, are considered. It also examines the effectiveness of such measures, the obstacles that arise in the way of their implementation.

T. Ariebowo also explores education during the COVID-19 pandemic [19]. These questions relate to the autonomy of learning. To do this, assessments of teaching are given, in particular the process of teaching English. The effectiveness of online learning is also considered. In this case, the goals and preferences of students were taken into account. The strengths and weaknesses of such a learning process were identified.

The study [20] addresses the problem of the impact of COVID-19 on mental health. This study is based on the PHQ-ADS questionnaire that was administered to women. The results showed a link between women's health and the development of the COVID-19 pandemic. These data can be used to adjust treatment protocols, develop strategies in healthcare policy, and identify the most vulnerable groups of patients.

D. Ulenaers, J. Grosemans, W. Schrooten, and J. Bergs study nursing student education in a pandemic [21]. In this study, students from nine Belgian schools were considered. To do this, a survey of students was conducted on five parameters, which were subjected to statistical processing and analysis. Data were obtained on the need to focus on psychological support. This made it possible to adjust training programs and increase support for such personnel from the state.

M. Riccaboni and L. Verginer are studying the impact of COVID-19 on scientific research [22]. Particular attention is paid to the analysis of state support for such processes. For these purposes, the scientific base of PubMed was used. A significant increase in the number of works devoted to the problems of COVID-19 was noted. At the same time, such work has supplanted research on clinical trials. It is also noted that such a bias in research could be caused by editorial policy.

A. Kumar, P. K. Gupta and A. Srivastava conduct a systematic review of technologies to combat the COVID-19 pandemic [23]. A special place is also given to forecasting methods for developing strategies to combat the coronavirus disease pandemic. For these purposes, various databases are used, their processing by modern methods of analysis. As a result, conditions for the application of possible approaches for data analysis are obtained, as well as limitations on their application are identified.

The study [24] examines the impact of the COVID-19 pandemic on older people. The authors note the significant impact of coronavirus on the lives of people, especially those who have become lonely and are experiencing isolation. This category primarily includes the age population. Based on this, the article deals with the protection of such people. For these purposes, various databases are summarized and processed by appropriate methods. A total of 13,452 separate studies were also reviewed. As a result, recommendations were received for the development of protective measures for the elderly.

M. A. Hincapié, J. C. Gallego, A. Gempeler, J. A. Piñeros, D. Nasner and M. F. Escobar consider the feasibility and usefulness of telemedicine during coronavirus disease [25]. The authors summarize the relevant literature by considering various information retrieval strategies. The authors reviewed papers from the United States, India, and China. This made it possible to select and justify the necessary solutions for the development of telemedicine.

We see the complexity and versatility of the problematics of the question posed. At the same time, we note the importance of considering possible methods and approaches to forecasting COVID-19.

3. Analysis of Forecasting Methods Under COVID Conditions

When forecasting COVID, one needs to know the variation of external disturbing influences in order to obtain a so-called normative forecast. A number of such IF-TO forecasts are sometimes referred to as future scenarios, and experts are asked to select the scenario that best fulfils the objective of SIAS [26], [27]. The easiest way to make projections is to assume that things will continue, as they have been so far (status quo hypothesis). Normative forecasts often take the form of normative scenarios, each of which responds to one of the variations in the decision maker's control responses and perturbing influences.

The different approaches to prediction differ in the amount of a priori information required for prediction on the object under study, on the measurable and non-measurable characteristics, on the state and changes in its environment.

The deterministic approach assumes that all information is available a priori or can be obtained with sufficient accuracy.

The stochastic approach takes into account the influence of intervening factors and noise, treating the characteristics of interest as random variables whose probabilistic parameters are obtained through sampling realizations.

Most Data Mining tools are based on two technologies: machine learning and visualization (visual representation of information) [28], [29]. The quality of visualization is determined by the capabilities of graphical representation of data values. Varying the graphical representation by changing colors, shapes and other elements makes it easier to identify hidden dependencies.

The effectiveness of machine learning techniques is largely determined by their ability to explore more data relationships than humans can.

Both technologies complement each other in performing Data Mining analysis. Visualization is used to look for exceptions, common trends and dependencies and helps in data mining at the beginning of a project. Machine learning is used later to look for dependencies in an already debugged project.

Machine learning involves the use of various techniques such as decision trees; associative rules; genetic algorithms and Bayesian-type neural networks.

Decision trees are designed to classify data, they use weights to allocate data items into progressively smaller groups. The associative rules method classifies data based on a set of rules similar to those in expert systems. These rules can be generated using a process of searching and checking combinations of rules, or by extracting rules from decision trees. In neural networks, knowledge is represented in the form of links connecting a set of nodes. The strength of the links determines the dependencies between data factors.

Each method has advantages and disadvantages. The advantage of decision trees and associative rules is their readability - they resemble natural language sentences. However, with a large number of data factors, it can be very difficult to understand the meaning of such a representation. The disadvantage is that they are not designed for wide numerical intervals. This is because each rule or node in the decision tree represents a single relationship (dependency, relation). Too many rules or nodes would be needed to represent dependencies for a large range of values. The advantage of neural networks is the compact representation of numerical relationships for a wide range of values. The disadvantage is the complexity of interpretation.

There is a wide range of tools available to support Data Mining projects. These include both commonly available visualization and machine learning algorithms, as well as sophisticated software packages that use both strategies running on parallel processors. The cost of the latter can reach several hundred thousand dollars. Finding the best tool for a Data Mining solution depends on a number of conditions, such as the purpose of the project (e.g. consumer shopping basket analysis) and the size of the database being examined. Flexibility is very important in the choice of tools and algorithms, as different results can be obtained depending on the choice of strategy.

For the analysis of the natural environment, methods that are now widely used in the literature are called Intelligent Data Analysis (IDA), a term that corresponds to Data Mining, Online Analytical Processing, OLAP (operational data analysis), Knowledge Discovery or Intelligent Data Analysis [30]-[32]. The term IDA seems a bit ad-hoc. IDA methods are hardly more 'intelligent' than those used in other sections of software, but since the term is well-established, we will use it.

Data mining is the application of processing algorithms to identify hidden trends, patterns, relationships and process perspectives that help to improve the quality of decision-making. All methods currently used in data mining are logical generalizations of various analytical approaches that have been known for decades. The novelty of IAD lies in the broader application of these methods to management, which has been made possible by the increased availability of data and cheaper computing. Moreover, until relatively recently there were no computer-based IAD methods with user-friendly interfaces. The growing interest in intelligent analysis tools is partly due to interface improvements that have made them available for use by business professionals, but mainly due to the increased demands on analysis results, the dramatic increase in the volume of information processed, the increasing complexity of the tasks to be performed and the time constraints of situational analysis and decision-making.

Methods for self-organization of predictive models can be considered as a method for adaptive synthesis (adaptation) of PSOI. If a priori uncertainty refers only to the system parameters at constant (e.g., given structure), then the known algorithms of parametric adaptation and learning can be applied. If the structure is also uncertain, self-organization algorithms are required for structural identification.

For self-organization of COVID predictive model we need three conditions:

1) There is an initial COVID situation (set of reference functions);

2) There is a mechanism for COVID random changes (mutations) (set of candidate models);

3) There is a selection mechanism by which these mutations can be evaluated in terms of their usefulness for improving the impact on COVID (self-organization algorithm).

The process of self-organization is related to the reduction of entropy. In this sense, the principles of self-organization are the subject of extensive COVID research.

At first level, all methods are divided into three classes on the basis of "information basis of method". Factographic methods are based on actually available information material about COVID - the object of prediction and its past development. Expert methods are based on information supplied by expert experts in the process of systematic procedures for identifying and summarizing this opinion.

Combined methods are allocated to a separate class so that methods with a mixed information base, in which factual and expert information is used as primary COVID information, can be referred to it. For example, in expert elicitation, participants are provided with numerical COVID information or factual predictions, or, conversely, in trend extrapolation, expert COVID estimates are used along with actual data.

Combination methods should not include those methods of COVID forecasting that apply mathematical processing methods to expert input information or expert evaluation of factual input information. In most cases, they fit reasonably well into the first or second class listed above.

These classes are further divided into subclasses based on the principles of information processing. Statistical methods combine a set of methods for processing quantitative information about the object of forecasting on the principle of identifying mathematical patterns of development contained in it and mathematical relationships of characteristics in order to obtain forecast models.

The analogy methods aim to identify similarities in the patterns of development of various processes and make predictions on this basis. Leading methods of forecasting are based on certain principles of special processing of scientific and technical information, implementing in the forecast its property to lead the development of scientific and technological progress.

Expert methods are divided into two subclasses. Direct expert evaluations are based on the principle of obtaining and processing an independent generalised opinion of a collective of experts (or one of them) in the absence of influence on the opinion of each expert by the opinion of another expert and the opinion of the collective. Expert evaluations with feedback in one form or another embody the feedback principle by influencing the evaluation of an expert group (one expert) by the opinion previously received from this group or from one of its experts.

The third level of classification divides forecasting methods into types according to the classification attribute "method apparatus". Each type combines methods that have as their basis the same apparatus for their implementation. Thus, statistical methods by type are divided into methods of extrapolation and interpolation; methods using the apparatus of regression and correlation analysis; methods using factor analysis.

The class of analogy methods is subdivided into mathematical and historical analogy methods. The former use objects of a different physical nature, another field of science, another branch of technology as an analogue for the predicted object, but have a mathematical description of the development process that coincides with the object/projection. The latter use as an analogue processes of the same physical nature, which are ahead in time of COVID development.

The anticipation methods can be divided into methods for studying the dynamics of S&T information; methods for investigating and estimating the level of COVID in different countries. The first mainly uses the construction of quantitative qualitative dynamic series based on different types of studies [33] and the analysis and forecasting of the corresponding COVID propagation conditions on their basis. The second type of methods uses a special apparatus of analysis of quantitative and qualitative information contained in studies [33] to characterize the level of quality of the existing situation, which is related to COVID.

Direct expert assessments of patient condition and COVID parameters on the basis of the hardware implementation of clinical studies (data on the patient's immune system indicators, medico-biological images of human body elements) are divided into types of expert primary questioning to identify the primary diagnosis, its clarification and expert intelligent system analysis of the patient. In the first case, special procedures are used to generate questions, organize answers using proven successful bots, process the patient's answers and generate a COVID diagnosis, taking into account the continuous improvement of medical research results and observation of the changed COVID situation. In the second, the primary research apparatus is focused patient analysis and dissemination of COVID for the purpose of prediction by a medical expert or team of experts who themselves pose and solve questions leading to a systematic approach goal.

Feedback-based expert reviews have three types of methods in their apparatus: expert questioning; idea generation; game modeling, artificial intelligence and machine learning methods. The first type is characterized by procedures of regulated non-contact interviewing of experts with intermittent feedback in the sense of system approach implementation discussed above. The second is based on procedures of direct communication between experts in the process of exchanging opinions on the problem posed by COVID propagation. It is characterized by the absence of questions and answers and aims at mutual stimulation of experts' creative activity. The third type uses the apparatus of game theory, artificial intelligence (AI), machine learning (ML) and their applied sections [28]. As a rule, they are realized on the combination of dynamic interaction of expert teams and the computer information-analytical system of the situation centre, simulating the object of forecasting in possible future situations with the use of AI and MO technologies.

Finally, the last, fourth, level of classification subdivides types of methods of the third level into separate methods and groups of methods according to some local for each type sets of classification features, of which it is impossible to specify one common symptomatic criterion for the whole COVID level.

4. Wavelet Coherence as Analysis Tool

One of the approaches to the analysis and forecasting of the conditions for the development of COVID-19 can be the use of wavelet methodology. Wavelet coherence estimates should be singled out among such approaches [34], [35]. This allows you to evaluate the mutual dynamics of the data and understand their relationships. As a consequence, the assessment of relationships allows predictions about the development of

COVID-19. Wavelet coherence estimates are widely used for the analysis of various data [36]-[41].

On Fig. 1 shows an estimate of the relationship between the total number of patients with COVID-19 and the number of deaths from COVID-19 (for the early stages of the development of a pandemic).

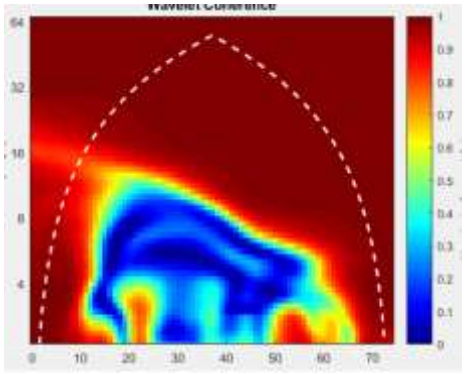

Figure 1: Relationship between COVID-19 cases and COVID-19 deaths [42]

We can observe the differences in the presented connections. It should also be noted that there is a change in the depth of relationships between cases of infection and mortality from COVID-19. This helps to understand the nature of such links and assess the likelihood of their occurrence in subsequent periods.

In addition to the data in Fig. 1 should also take into account the ratio of infected and recovered from COVID-19. This allows you to better understand the dynamics of the data, build more reliable forecasts.

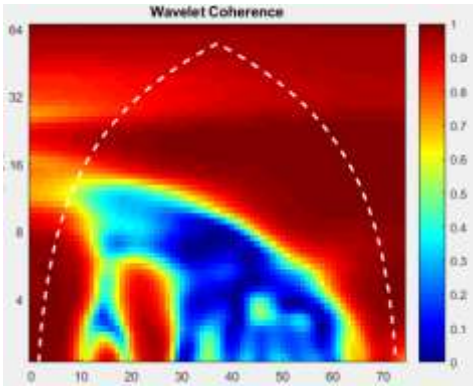

Figure 2: Estimates of wavelet coherence between the total numbers of infected and recovered from COVID-19 [42]

We see the comparability of the data in Fig. 1 and Fig. 2. This indicates the expediency of using wavelet coherence in this type of analysis. It also allows you to build more accurate forecasts.

5. Conclusion

The paper considers some issues of building predictive models for assessing the development of diseases based on the COVID-19 pandemic. A review of the relevant literature was carried out. The problematic aspects of forecasting in the analysis of the development of diseases are highlighted. The possibilities of modifying known methods for obtaining estimates of the development of COVID-19 are considered.

As an example, the possibility of analysis based on wavelet coherence estimates for studying the COVID-19 pandemic is considered. It is shown that such results can be the basis for obtaining reliable forecasts.

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