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Situational-linguistic model of Covid-19 as a tool for ensuring the prevention and management of the pandemic

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Abstract:

Modeling is one of the tools for cognition and study of phenomena, processes, and objects. This approach allows you to assess the current situation and make the most effective decisions. It also becomes possible to evaluate possible solutions without negatively impacting the current situation. Based on this, the work examines the key aspects of constructing a situational linguistic model in the context of the development of a pandemic. The Covid-19 pandemic is considered such a pandemic. A generalized concept of the situational-linguistic model of Covid-19 is presented.

Key words: Model, Covid-19, Prevention, Management, Pandemic

Introduction

Humanity is constantly faced with various kinds of disasters and shocks in the form of natural disasters or pandemics. A striking example of the latter is the formation and development of the Covid-19 pandemic, which took many lives and caused significant economic damage [1]-[3].

If natural disasters are caused by a number of objective and subjective factors, then they can be predicted and an appropriate warning system can be built in order to minimize possible consequences.

It is much more difficult in the case of the emergence and development of pandemics, which are very difficult to predict. For these purposes, various methods and approaches should be used to substantiate and construct the necessary models [4]-

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[10]. It is also possible to use methods and approaches that have proven themselves in other areas of research [11]-[14]. Based on the above, we draw attention to the possibility of using situational linguistic modeling as a tool for ensuring the prevention and management of a pandemic, using Covid-19 as an example. This is precisely the main purpose of this article.

Related works

The use of various models to study the emergence and development of the Covid-19 pandemic is the basis of many studies. Here you can find the use of various theories and approaches.

N. P. Jewell, J. A. Lewnard, and B. L. Jewell study predictive mathematical models of the Covid-19 pandemic [15]. The authors note that many mathematical models have been created to predict the future development of the Covid-19 epidemic. At the same time, it is important to understand when a decrease in deaths occurs and what measures need to be taken to achieve this. However, in forecasting the future of the Covid-19 pandemic, many key assumptions were based on limited data. Therefore, it is important to select the fundamental and most influential factors for prognosis.

S. Khajanchi, K. Sarkar, J. Mondal, K. S. Nisar and S. F. Abdelwahab studied models with strategic intervention in the course of a pandemic [16]. This is important for health planning and pandemic control. For these purposes, the SEIR model is used, which is complemented by strategies for tracking possible contacts of the patient and subsequent hospitalization. To identify the most effective parameters, an analysis is carried out using partial rank correlation coefficients [16].

E. Iboi, O. O. Sharomi, C. Ngonghala and A. B. Gumel base their mathematical model on data from the Covid-19 pandemic in Nigeria [17]. This analysis is based on the Kermack-McKendrick model, which takes the form of a deterministic system of nonlinear differential equations. At the same time, the authors substantiated that Covid-19 can be effectively controlled using social distancing measures. This allows the development of appropriate measures in the health system.

S. L. Chang, N. Harding, C. Zachreson, O. M. Cliff and M. Prokopenko study the transmission and control of the Covid-19 pandemic [18]. This analysis is carried out on data from Australia. The authors apply agent-based modeling using fine-

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grained computer simulation [18]. The work also examines intervention strategies for the development of the Covid-19 pandemic and possible trade-offs.

The study [19] performs a non-standard computational analysis of a stochastic model of the Covid-19 pandemic. The authors use two stochastic modeling methods: transition probabilities and parametric perturbation methods. The work also uses such computational methods as: Euler Maruyama, stochastic Euler and stochastic Runge Kutta to study the dynamics of data [19]. Some other models are also considered in comparison with the proposed approach, which allows us to evaluate the results obtained.

R. Alguliyev, R. Aliguliyev and F. Yusifov use graphical modeling to track the spread of the Covid-19 pandemic [20]. This allows you to analyze the factors influencing the spread of the disease and its main characteristics. The authors emphasize that the use of a graph to model a pandemic allows one to take into account many factors influencing the epidemiological process and conduct numerical experiments. This approach allows for a reverse analysis of the spread as a result of dynamically accounting for identified cases of infection in the model [20].

The study [21] analyzes the transport effect of the Covid-19 pandemic. In particular, the authors consider an extension of the SIRD model to the regional spread of Covid-19 in France. A network model of pandemic transmission between French regions is presented based on a regional extended model. This allows you to track the dynamics of the spread of Covid-19.

The study [22] uses machine learning methods to predict the development of the Covid-19 pandemic. Various data sets are used for these purposes. The authors proposed a machine learning model that makes it possible to predict the spread of Covid-19 and the expected period after which the virus can be stopped.

A. Abbes, A. Ouannas, N. Shawagfeh and H. Jahanshahi explore a discrete fractional order model for studying Covid-19 [23]. This allows you to analyze the stability of the equilibrium point. It is shown that the dynamic behavior of the model changes from stable to chaotic behavior when fractional orders change.

We see a variety of approaches being used in studying the Covid-19 pandemic. However, new and abundant data make it necessary to consider new approaches to modeling the spread of the pandemic.

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Situation-linguistic COVID model: general principles

Tools for COVID prevention and management provision and decision making are developed on the basis of accumulated ontological and case study experience and current COVID process data. To address the problem formulated above, tool research is currently being developed and uses the so-called logical inference based on precedents and ontologies. This is a decision-making method that reuses knowledge about previous situations [12].

To model COVID, let us consider the possibilities of using a product-frame hierarchy architecture. A product-frame hierarchy architecture is based on a frame-based knowledge representation in which a frame hierarchy with an inheritance relation and active slots is taken as the basis, and the output is carried out by product rules. This approach naturally combines static knowledge about the problem to be solved in the form of slot values and structural knowledge about the domain in the form of an inheritance hierarchy.

Thus, a frame system can be represented in the form of:

$W : S \rightarrow I,$

where I – a set of frames, $S = \{s_i\}$, $i = \overline{1,n}$ – a finite set of slots of the form $\left\langle v, d, \left\{D_j\right\}\right\rangle$, which includes the current value of the slot $v = \left\langle v_1, v_2, \dots v_l \right\rangle \in T$ and the default value $d = \left\langle d_1, d_2, \dots, d_k \right\rangle \in T$, the procedures of the daemons $\left\{D_j\right\}$.

The inheritance relation: is induced by the slot with reserved name parent: $F : G \Leftrightarrow \|F(\text{parent})\| = G$. The typical operation of frame specification by pattern is implemented by implicitly including a rule $F(\text{parent}) \leftarrow \text{match}(F,G)$ in the model. When considering multiple inheritance, the parent slot is assumed to be of list type $F : G \Leftrightarrow G \in \|F(\text{parent})\|$.

The output parameter values (the resulting frame $- I_P$) is inferred if the values of the input parameters (query frame – I_3, consisting of a subset of $v \times d$) are clear:

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$$L:\begin{cases} \text{If } \langle v_1^1, \ldots, v_l^1; d_1^1, \ldots d_k^1 \rangle \text{ TO } S_1^p, \\ \text{If } \langle v_1^2, \ldots, v_l^2; d_1^2, \ldots d_k^2 \rangle \text{ TO } S_2^p, \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ \text{If } \langle v_1^n, \ldots, v_l^n; d_1^n, \ldots d_k^n \rangle \text{ TO } S_n^p. \end{cases}$$

The resulting frame I_p is a set of v and d, belonging to different frames. Thus I_p – the output of the product system represented by the following view:

$$\langle S_1^p, S_2^p, \ldots, S_n^p \rangle \to I^p.$$

In order to obtain the set goal, it is necessary to solve the following tasks:

to realize the construction of predicate queries and their modification, which will be a formal-logical apparatus for describing and studying the processes of updating and modification of databases and knowledge,

Define rules of logical inference based on databases and knowledge for the COVID situation.

Overseas scientists have developed a method to estimate the likelihood of deaths from COVID based on information collected from patients' electronic medical records. However, with a broken healthcare system, advanced compartmentalization – to which all countries are prone to varying degrees - and incomplete, inaccurate and inadequate statistics, it is impossible to move towards effective steps to combat COVID. Specialists have identified 46 diseases that would be risk factors for death if infected with the coronavirus. Besides the lethal dangers of COVID, there are at least 200-300 other diseases which should not be forgotten and should not be given over to "fighting" COVID and thereby increasing the "excess mortality rate".

Definition. Let $\Pi = \{\pi_1^{m_1}, \pi_2^{m_2}, \ldots \pi_r^{m_r}, \ldots\}$be the set of predicate symbols, respectively, $m_1, m_2, \ldots m_r, \ldots,$ which are called predicate constants. A variable predicate symbol, or simply a predicate is a sign (or a sequence of signs) denoting an arbitrary element of Π. The set Π will be called the set of variable predicate's values.

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Let P be a variable predicate symbol, the value set of which consists of predicate constants of the same degree of arity equal to m, having the form $\pi_j^m = \pi_j(x_1,...,x_m)$, $i = 1,2,...r,..$, where $x_1,...,x_m$ - symbols of subject (individual) variables. Then P is called an m-ar variable predicate, or simply a predicate, and is denoted by $P(x_1,...,x_m)$. To interpret a m- -ar variable predicate $P(x_1,...,x_m)$ it is necessary to specify the COVID regions $D_1, D_2,...,D_m$ of the COVID variables $x_1,...,x_m$. Usually $D_1 = D_2 = ... = D_m = D$. Moreover, for each predicate constant included in Π, one has to define a mapping $D_1 \times D_2 \times ... \times D_m$ to $\{T, F\}$. Thus, the interpretation of т ar variable predicate $P(x_1,...,x_m)$ consists of a set of interpretations of its values $I(P) = \{I(\pi_1^m), I(\pi_2^m),..., I(\pi_r^m),...\}$. By replacing the symbols of the subject variables $x_1,...,x_m$ in the predicate constants Π m objects from $D_1 \times D_2 \times ... \times D_m$ we obtain a set of statements about this object. Having $m = 1$ The predicate describes a "property" of the object, having $m > 1$ he predicate describes a "relation" between m objects.

We will encode the values of predicates by means of matching them with points of some Euclidean space. It is convenient to encode predicate values with straight line numbers R^1. To the value of a predicate with an index i we put a one-to-one correspondence with a point $g(i)$, equal to $g(i) = ai + b$, where a is some positive number and b is an arbitrary number. Numbers a and b define respectively the scale and the origin of the predicate values on the line R^1. In the knowledge analysis, we will also use other ways of encoding predicate values, which will be discussed below.

The knowledge base editor is needed to create and edit the knowledge base, write it to a file and open saved files. It should visualize the graph on the monitor screen and display parameters of the graph vertices, allow the user to edit programs related to the vertices and translate them. The translation of the source program is made into the intermediate code as it allows significantly speed up the logical output as a whole. Proceeding from these tasks, the following requirements to the editor can be formulated. The editor should provide:

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Possibility to create and delete vertices. When creating a vertex in a graph the editor must initialize the vertex name, state and type fields.

Possibility to change the following graph vertices parameters: name, state, type. The names of the graph vertices must be unique.

Ability to establish and break an ancestor-descendant relationship between vertices in the graph.

Displaying the graph monitor and its vertex parameters after each action of a-c.

Editing the program for each node. The graph node program language should implement the following instructions:

I. Conditional instruction (if).
II. Instruction of loop (while, do while, for).
III. Arithmetic operations.
IV. Type declaration.
V. Declaring variables.
VI. Declaring constants.
VII. Instructions affecting the course of logical analysis.
VIII. Instructions for interaction with receptors and effectors.

Translation of graph node programs and diagnosis of errors found in those programs. Saving of translated programmes into separate files. Saving the knowledge base in a file in which the program for each vertex of the graph is written in the source language.

The development of decision-support databases and knowledge for the COVID situation is done in the following sequence:

1. A preliminary, systematic analysis of the natural environment parameters in a given area is carried out. The conditions of COVID occurrence are identified.

2. A generalized database and knowledge base {Bdk} is formed.

3. The set of notions «$\{q_i\}$ subject (medic, rescuer, dispatcher of rescue service, etc.) – $\{r_i\}$ control action (to call the rescue medical service, to report to the situational centre, to give a message about COVID, etc.) is revealed.) – $\{e_i\}$ object (vehicles, helicopter, etc.)" for COVID and close virus situations of different origin and application.

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4. A set of situation descriptions is generated in a situation description language of the type

$$C_j = \{q_1 r_2 e_5, q_1 r_2 e_4, q_3 r_1 e_1, q_2 r_2 e_2, q_2 r_2 e_3, q_2 r_2 e_6, q_2 r_3 e_7\},$$

where $j = \overline{1, N}$ is the number of situations.

5. As a result of micrositeuation proximity analysis, close COVID situations are identified.

6. The accumulated set of close situations is transferred to the subsystem of decision-making (DDP) of the anticovoidal situation centre, which prepares recommendations for the decision maker (DM).

The implementation of the tasks in the DDP for the prevention and management of COVID situations is performed on a set of close situations in the following sequence:

1. Scenarios of possible COVID {Bdk} development are generated based on the results of studies that are provided in the literature.

2. Assessing the scenarios in terms of time needed to prevent COVID and loss of human and material resources.

3. Generation of proposals to the decision maker (LPR).

The generation of possible COVID scenarios can be done by: software implementation of analytical or simulation models, using expert systems, generating scenarios by combining different operations given by the LPR or taken from a generalized database and knowledge {Bdk}, and finally using an approach that is called situational management.

Conclusion

Thus, the work examines the general principles of developing a situational-linguistic model for assessing the development of a pandemic using the example of coronavirus infection. The main identifiers of such a model are identified and an

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algorithm for its implementation for the prevention and management of COVID situations is presented.

The work also discusses issues of predictive modeling for analyzing the development of Covid-19. The main points of their use and improvement are summarized.

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