Decision support procedures for decision making in a COVID condition

Boboyorov Sardor Uchqun o‘g‘li[1], Kuzomin Oleksandr[2], Lyashenko Vyacheslav[3]

sardorboboyorov020@gmail.com

lyashenko.vyacheslav@gmail.com

[1]Tashkent Medical Academy Termiz branch, Uzbekistan

[2]Department of Informatics, Kharkiv National University of Radio Electronics, Ukraine

[3]Department of Media Systems and Technology, Kharkiv National University of Radio Electronics, Ukraine

Abstract:

Any negative situation requires an immediate response to its occurrence and further development. This is especially true in the presence of epidemiological factors in order to minimize various risks. Based on data on COVID-19, the work discusses general approaches to building a procedure to support relevant decision-making. The main generalizations and formalization in the form of mathematical relationships are presented. Attention is also paid to the key features of the solution procedures under consideration.

Key words: COVID-19, Risks, Pandemic, Methods, Models, Decision making, Support procedures

Introduction

The emergence and development of unforeseen situations necessitate the adoption of operational decisions [1]-[3]. Such decisions should ensure the minimization of possible risks and help overcome emerging negative situations and their consequences. This fully applies to situations that are determined by epidemiological characteristics and characterize a certain disease that spreads rapidly and causes the development of negative consequences. As an example of the development of a negative situation, we should point out the COVID-19 pandemic, which has claimed many lives and had a negative impact on people’s livelihoods and global economic development [4]-[6].

In order to overcome the consequences of the COVID-19 pandemic and predict the occurrence of new outbreaks, various mathematical models have been developed [7], [8]. This contributed to reducing relevant risks and developing decision-making procedures in the current situation. At the same time, for such purposes it is possible to use various non-standard models and approaches that have proven themselves in other areas of research [9]-[15]. It should also be noted that the decision support system should take into account the development of negative situations in various spheres of life. This will ultimately determine the feasibility of using various methods and approaches to implement decision support as an integral system.

Thus, the main goal of this work is to summarize the main approaches to developing a decision support procedure in the context of COVID.

Related work

Like the basics of COVID modeling, there are many articles covering decision-making issues.

For example, work [16] pays attention to decision making at the political level. The study analyzes the various factors that were most prominent during such a crisis. It also takes into account the variability of the environment in which the COVID pandemic is unfolding. This imposes its own formal limitations and creates uncertainty. Therefore, the authors emphasize that decision-making theory creates all the prerequisites and conditions for the formation of the most adequate political conclusions.

In the study [17], attention is paid to the procedures for making multi-criteria decisions related to the COVID-19 pandemic. The article provides an in-depth theoretical analysis. The authors emphasize the importance of such procedures during the initial stages of a pandemic outbreak. In this case, decisions must be applied taking into account many criteria and influencing factors. Various information can be used for these purposes. Overall, this work is a good reference for review and development for decision making in various areas against COVID.

O. F. Norheim and co-authors consider possible compromise solutions in response to the challenges of the COVID-19 pandemic [18]. In this case, priority is given to inclusive decision-making. The authors emphasize the importance of deliberative decision making. The work notes that deliberative processes are capable of taking into account many opinions and finding the most compromise solutions. The study argues for such open and inclusive decision-making.

A. Belhadi, S. S. Kamble, S. A. R. Khan, F. E. Touriki and M. D. Kumar explore the issues of infectious waste management [19], which is also an important and relevant point. For these purposes, the work considers an integrated decision-making system for selecting sustainable technologies. The authors offer a comprehensive assessment for such decisions. An integrated approach to the disposal of relevant waste is also taken into account. The advantages and disadvantages of the solutions under consideration are noted.

The article by P. Ferrinho and his co-authors draws attention to the key principles of decision-making in healthcare in the context of COVID [20]. The authors emphasize that fundamental principles must be followed to make decisions during a pandemic, even in the absence of reliable evidence. However, such principles need to be implemented comprehensively, using a holistic systems approach to health policy, adapted to the specifics of the local context [20].

R. Gupta, B. Rathore, A. Srivastava and B. Biswas discuss a decision-making framework for identifying regions vulnerable to transmission of the COVID-19 pandemic [21]. For these purposes, the authors consider a hybrid fuzzy decision-making framework for COVID-19 analysis. This is based on identifying the main factors for classifying vulnerable regions. In this way, separate clusters are formed in terms of their criticality for the transmission of COVID-19. This research contributes to the development of decision analysis and risk management methods in healthcare [21].

The paper [22] discusses the issues of pediatric decision-making during surgical interventions in the context of COVID-19. This is necessary to effectively use hospital resources, as well as to weigh the risks of surgery. Examples include selected cases such as oncology, trauma, minimally invasive procedures and extracorporeal membrane oxygenation [22].

X. Li, H. Liao and Z. Wen propose a model for managing the behavior of people faced with decision-making problems during the COVID-19 outbreak [23]. Particular attention is paid to group decision making. As a result, a consensus model was proposed to control the non-cooperative behavior of experts in large-scale group decision-making problems [23]. This model implements a dynamic weighting mechanism to increase the level of consensus in the group when making decisions.

We note the diversity of work on decision making during the COVID-19 pandemic. This emphasizes the importance of the problem under consideration. At the same time, new research helps to better understand what is happening and optimize decision-making.

Basics of formalizing decision-making in COVID conditions

It is expedient to use connection of quantitative and qualitative data about condition of patient and environment, presented in generalized database and knowledge for creation of information space of control object in condition, which enables to increase reliability, speed of data processing, provide timely development prognosis and decision making concerning management in condition.

The state, design hardware and software solution for decision making under conditions of $Pr = \langle A_p, K_p, Z_p, P, G \rangle$, т is also characterized by means of situations and concepts included in them. When designing, a developer finds himself in a certain situation, which is characterized by a group of interrelated notions that describe this situation. Each time he/she finds himself/herself in a pandemic situation that is already known and for which there is a group of rational solutions, it is possible to use the solutions associated with this situation.

The microsituation corresponds тройке controlling action in conditions - object (patients and resource for prevention and elimination of consequences), with which the human intellect operates)" [24] .The subject – LPR (health worker), is the central concept, the controlling action - context and the object is a secondary concept. In the general case, the sequences "subject - controlling action - subject - controlling action ... - object" [25], which corresponds to the case where the secondary concept is the central concept of another microsituation.

A generalized situation relatively comprises a set of concepts, each of which reflects its properties in some of its characteristic categories. The concepts are grouped into categories according to characteristic.

Context-dependent language is used in the tools for constructing the knowledge base of the specialized complex in the conditions. In particular, the language of fuzzy logic has been chosen. This approach has three main distinctive features:

1. Instead of or in addition to numerical quantitative variables, fuzzy values and so-called "linguistic" variables are used, which link the situation around – $S = \{s_i\}$ $(i = \overline{1, n})$, the goal Z и тройку «subject (LPR) - control action ($\Im$) – object (resource – Σ)» triplet. Microsituations, which are defined on a set of quantitative parameters characterizing the patient’s condition in conditions – {X} 3 (after using Data Mining apparatus), are "connected" with qualitative or linguistic data.

2. Simple relations between variables of patient's condition and environment are described by means of fuzzy statements - predicates.

3. Complex relations are described by fuzzy algorithms using membership functions $\{\mu_i\}$ $i = \overline{1, k}$, because the classification of situations has ambiguous meaning and can take intermediate values between extreme values [25].

The main laboriousness of the process of knowledge extraction by analysts from the subject area experts is associated with the fact that the participants of the process operate with different concepts and they need a common language of communication [24].

Intellectual-verbal communication between people is based on linking object representations, concepts and words. Problems in intellectual-verbal communication arise when the wrong words are used. This occurs when there are different associations between a concept and a word.

An intellectual-verbal representation of a situation consists of many concepts. In addition, the situation can be resolved in a risk-based way. The elements of the specialized complex in the conditions are selected according to the analysis of situations from the sets of variants of management decisions, offered in the algorithmic complex and using the best, optimal in the sense of time costs for the realization of management decisions of suitable solutions.

This selection or "selection" of precedents is ensured by comparing the current, problematic micro-situation with a set of reference micro-situations. In the metric space similarity of precedent and problem situation can be estimated in the following sequence:

A metric in the space of all significant parameters is introduced.

In this space a point which corresponds to the problem microsituation can be defined.

Based on this metric, the closest point to it is found, substituting for reuse, tested, the best fit in the situation being analysed - the control action.

Accordingly, the selection methodology has the following sequence:

The set of situations $s_i = \left\langle e_i, K_e, X, \Im, \Sigma \right\rangle$ is divided into a finite number of classes Ω_ν, $\nu = \overline{1, m}$, a finite number φ_ν .of situations are found within the class Ω_ν. Situations are defined on the set of parameters $x_{\nu_1}, x_{\nu_2}, ..., x_{\nu_{1n}}$, where $\nu_1, \nu_{12}, ..., \nu_n \in \overline{1, n}$. The sets $x_{\nu_1}, x_{\nu_2}, ..., x_{\nu_{1n}}$ for different classes may not coincide.

The boundaries of the class are defined, for this purpose let us denote by $\chi^j_{\nu\varphi}$ ($j \in \overline{1, n}$, $\varphi \in \overline{1, \varphi_\nu}$, $\nu \in \overline{1, m}$) $-$ the value of j parameter, φ $-$ that situation of the class ν, then the boundaries of the class ν by the parameter j can be composed of pairs of $\left\{ \min_k \left[\chi^j_{\nu\varphi} \right], \max_k \left[\chi^j_{\nu\varphi} \right] \right\}$. Geometrically the class can be represented as a multidimensional parallelepiped.

To evaluate a problem microsituation, which has been identified at the stage of preliminary regression analysis, classification and prediction (assignment to a class of situations in the conditions [24], [25]) it is necessary to investigate this problem microsituation in order to identify close microsituations (precedents) and corresponding solutions for U and Σ.

It is necessary to determine the relation to the class Ω_ν of the problem microsituation ω. ω is defined by the values of the parameters $x_{\omega_1}, x_{\omega_2}, ..., x_{\omega_n}$, where $\omega_1, \omega_2, ..., \omega_n \in \overline{1, n}$. On the parameter space, we compare the projections of the classes with the problem microsituation of the overmatching parameters $\left\{ x_i \ (i = \overline{1, n}) \right\}$. We will assume that the problem microsituation ω can be attributed to the class Ω_ν, $\nu = \overline{1, m}$, if for any parameter x_{ω_i} we have

$$\min_k \left[\chi^j_{\nu\varphi} \right] \le x_{\omega_i} \le \max_k \left[\chi^j_{\nu\varphi} \right].$$

We construct a differential series of situations and a domain in the subspace of the situation parameters for which the projections of the classes overlap. They can be represented on the set of pairs of $\max_{\nu_\omega} \min_k \lfloor \chi^j_{\nu\varphi} \rfloor, \min_{\nu_\omega} \max_k \lfloor \chi^j_{\nu\varphi} \rfloor$ for all parameters $\{x_i \ (i = \overline{1, n})\}$.

A precedent Π (represented by the values of parameters $x_{\Pi_i}, ..., x_{\Pi_n}$ $(\Pi_1, ..., \Pi_n \in \overline{1, n})$) can be considered an analogue of a situation ω on classes ν_ω, if for each parameter x_{Π_i} there exists x_{ω_i} and the condition

$$\max_{\nu_\omega} \min_k \lfloor \chi^j_{\nu\varphi} \rfloor \le x_{\Pi_i} \le \min_{\nu_\omega} \max_k \lfloor \chi^j_{\nu\varphi} \rfloor.$$

A problematic microsituation ω can be assigned to more than one class. If only one class is chosen, all microsituations of the class ν_ω will be analogous ω.

It is proposed to use the so-called "proximity measure" instead of a metric, specifying a selection rule by some form. In this case, topological space is used instead of metric space. it is proposed to use the so-called "local context-dependent metrics". The distance between the problem microsituation ω and the precedent Π is equal to the difference of the number of classes Ω_ω, where the problem microsituation "got" and the number of classes of this number Ω_Π, where the precedent is $\nabla = \Omega_\omega - \Omega_\Pi$.

In the problem to be solved, the technical tools that are used for prevention and response can be regarded as a control object. Decision-making for such a control object should be provided by algorithmic and software complexes in conditions or information space.

Conclusion

Systems thinking go beyond individual actions to connections, causes and consequences. Systems approaches incorporate tools and frameworks to help us does that, and to act in a way that reflects the complex and interconnected characteristics of our world. Systems are not external. We are part of them and we influence them, as demonstrated in the 'butterfly effect' examples above. Linked to this, complexity is a field that seeks to understand and work with the uncertain, non-linear, adaptive, self-organizing nature of systems.

Coronavirus illustrates the need to bring systems thinking out of the clouds and into the mainstream. We must learn to think, act, and organize systemically, and develop processes, tools and technologies to help us. Based on this, the work examines the basics of formalizing decision-making in COVID conditions. This allows you to make the most effective decisions during a pandemic.

References:

1. Gunasekaran, A., Ngai, E. W., & McGAUGHEY, R. E. (2008). Information technology and systems justification. In Evaluating information systems (pp. 1-34). Routledge.
2. Chehade, S., & et al.. (2019, October). Modelling Interactions in Rescue Operations. In 2019 IEEE International Conference on Systems, Man and Cybernetics (SMC) (pp. 4118-4123). IEEE.
3. Lunde, A., & Braut, G. S. (2019). The concept of overcommitment in rescue operations: some theoretical aspects based on empirical data. Air Medical Journal, 38(5), 343-349.
4. Ciotti, M., & et al.. (2020). The COVID-19 pandemic. Critical reviews in clinical laboratory sciences, 57(6), 365-388.
5. Mustafa, S. K., & et al.. (2020). Brief review of the mathematical models for analyzing and forecasting transmission of COVID-19. Journal of critical reviews, 7(19), 4206-4210.
6. Fauci, A. S., Lane, H. C., & Redfield, R. R. (2020). Covid-19–navigating the uncharted. New England Journal of Medicine, 382(13), 1268-1269.
7. Khoshnaw, S. H., & et al.. (2020). A quantitative and qualitative analysis of the COVID–19 pandemic model. Chaos, Solitons & Fractals, 138, 109932.
8. Adiga, A., & et al.. (2020). Mathematical models for covid-19 pandemic: a comparative analysis. Journal of the Indian Institute of Science, 100(4), 793-807.
9. Baranova, V., & et al.. (2019, October). Stochastic Frontier Analysis and Wavelet Ideology in the Study of Emergence of Threats in the Financial Markets. In 2019 IEEE International Scientific-Practical Conference Problems of Infocommunications, Science and Technology (PIC S&T) (pp. 341-344). IEEE.
10. Слюніна, Т. Л., Бережний, Є. Б., & Ляшенко, В. В. (2007). Розвиток вітчизняної мережі банківських установ: особливості та регіональні аспекти. Вісник ХНУ ім. В. Н. Каразіна. Економічна серія, 755. 84–88.
11. Ляшенко В. В. (2007). Интерпретация и анализ статистических данных, описывающих процессы экономической динамики. Бизнес Информ, 9(2), 108-113.
12. Vasiurenko, O., & et al.. (2020). Spatial-Temporal Analysis the Dynamics of Changes on the Foreign Exchange Market: an Empirical Estimates from Ukraine. Journal of Asian Multicultural Research for Economy and Management Study, 1(2), 1-6.
13. Nevliudov, I., & et al.. (2020). Development of a cyber design modeling declarative Language for cyber physical production systems. J. Math. Comput. Sci., 11(1), 520-542.
14. Ahmad, M. A., & et al.. (2020). Wavelet coherence as a tool for markers selection in the diagnosis of kidney disease. International Journal of Emerging Trends in Engineering Research, 8(2), 378-383.
15. Mustafa, S. K., & et al.. (2021). Some aspects of modeling in the study of COVID-19 data. International Journal of Pharmaceutical Research, 4124-4129.
16. Berger, L., & et al.. (2020). Uncertainty and decision-making during a crisis: How to make policy decisions in the COVID-19 context?. University of Chicago, Becker Friedman Institute for economics working paper, (2020-95).
17. Alsalem, M. A., & et al.. (2022). Multi-criteria decision-making for coronavirus disease 2019 applications: a theoretical analysis review. Artificial Intelligence Review, 55(6), 4979-5062.

18. Norheim, O. F., & et al.. (2021). Difficult trade-offs in response to COVID-19: the case for open and inclusive decision making. Nature Medicine, 27(1), 10-13.

19. Belhadi, A., & et al.. (2020). Infectious waste management strategy during COVID-19 pandemic in Africa: an integrated decision-making framework for selecting sustainable technologies. Environmental Management, 66, 1085-1104.

20. Ferrinho, P., & et al.. (2020). Principalism in public health decision making in the context of the COVID-19 pandemic. The International Journal of Health Planning and Management, 35(5), 997-1000.

21. Gupta, R., & et al.. (2022). Decision-making framework for identifying regions vulnerable to transmission of COVID-19 pandemic. Computers & Industrial Engineering, 169, 108207.

22. DeFazio, J. R., & et al.. (2020). Development of pediatric surgical decision-making guidelines for COVID-19 in a New York City children's hospital. Journal of pediatric surgery, 55(8), 1427-1430.

23. Li, X., Liao, H., & Wen, Z. (2021). A consensus model to manage the non-cooperative behaviors of individuals in uncertain group decision making problems during the COVID-19 outbreak. Applied Soft Computing, 99, 106879.

24. Kuzemin, O., & Lyashenko, V. Microsituation Concept in GMES Decision Support Systems / A. Kuzemin, V. Lyashenko. Intelligent Data Processing in Global Monitoring for Environment and Security (pp. 217–238). – 2011 .– P, 217-238.

25. Boboyorov Sardor Uchqun o‘g‘li, Oleksandr Kuzomin, & Lyashenko Vyacheslav. (2023). Situational-linguistic model of Covid-19 as a tool for ensuring the prevention and management of the pandemic. Journal of Universal Science Research, 1(9), 111–121.