International Journal of Multidisciplinary Studies and Innovative Technologies

e-ISSN: 2602-4888
dergipark.org.tr/en/pub/ijmsit
Research Article

2022, 6 (2), 157-161
DOI: 10.36287/ijmsit.6.2.157
Received: Oct. 1, 2022; Accepted: Nov. 7, 2022

STOCHASTIC PROGRAMMABLE PARADIGM OF QUALITY CONTROL MANAGEMENT IN MULTI-AGENT SYSTEMS

Alibekkyzy Karlygash [1], Koshekov Kairat [2]

[1] *D. Serikbayev East Kazakhstan Technical University, Ust-Kamenogorsk, Kazakhstan (Karlygash.eleusizova@mail.ru) (ORCID: 0000-0002-6732-4363)*
[2] *Civil Aviation Academy , Almaty, Kazakhstan (kkoshekov@mail.ru) (ORCID: 0000-0002-9586-2310)*

Abstract – The article aims to develop a methodology for quantitative assessment and forecasting of the quality of decision-making in organizational and technical systems under the conditions of uncertainty of control agents. A stochastic model for predicting the reliability of control results and decision-making risks under the uncertainty of model agents was developed. The paper proposes a method for aggregating system structural uncertainties of the control and measurement process on the example of robust multi-aspect. The proposed mathematical application implements a multi-agent approach to solving the general problem of evaluating the robustness of control according to the criteria of «producer risk» and «consumer risk». For the purposes of modeling, such branches of mathematics and methods as probability theory and mathematical statistics, regression and correlation analysis, expert evaluation methods, simulation and structural-functional modeling, and agent-based approach are used.

A probabilistic model has been developed to assess and predict the reliability of control and decision-making risks under the uncertainty of system agents. The novelty of the proposed model consists in taking into account the statistical nature of normative values. The proposed mathematical application implements a dual method for solving the general problem of assessing the quality of the control process by the magnitude of risks in the decision-making system. In the first case, the problem of quantitative risk assessment is solved for given statistical characteristics of control agents, and in the second case, the necessary measurement accuracy is determined for given uncertainties and risk levels in the control system.

Process, model, probability, decision making, statistics, modeling, distribution law, pressure.

Keywords *– Process, model, probability, decision making, statistics, modeling.*

Citation: Alibekkyzy K, Koshekov K. (2022). Stochastic programmable paradigm of quality control management in multi-agent systems. International Journal of Multidisciplinary Studies and Innovative Technologies, 6(2): 157-161.

I. INTRODUCTION

The performance of a complex system is formally evaluated by an integrated set of some functionally significant indicators [1]. In accordance with the operating regulations, these indicators are subject to periodic monitoring by quantifying (measuring) their values and comparing the measurement results with the established standards. Standards are single – limit with a restriction from the bottom or top and two-limit-tolerance. The control system for the functional robustness of an object necessarily contains a control process . In [1,2], it is proposed to present control as a contextual process consisting of subprocesses: measurement, comparison of the measured value with normative values, analysis, decision-making and impact on the object in order to restore its functionality (feedback). Subprocesses are system agents in terms of their degree of autonomy and functionality [3,4,5]. Feedback determines the final effectiveness of the entire management process, since without feedback, management loses all meaning and turns into a contemplation of the situation.

The controlled parameters and technological processes of control in real conditions have a non-deterministic nature, and are mathematically approximated by some distribution laws. However, in the current practice, the evaluation of metrological quality of measurement is carried out only according to metrological passport data of tools for absolute and relative errors. This practice has known drawbacks, and therefore, the indicator «uncertainty» has been used in measurement technologies [6,7,8].

The indicator «uncertainty» appeared more than 30 years ago. According to [9], this approach is justified by the fact that «A parameter associated with the measurement result and characterizing the spread of values that can be attributed to the measured value with high probability». Uncertainties, as suggested by the authors, are divided into three classes: uncertainties associated with the incompleteness of our knowledge about the problem on which the decision is made;

uncertainty associated with the inability to accurately account for the reaction of the environment to our actions, and, finally, an inaccurate understanding of their goals by the decision-maker (LPR) [10]. The use of this approach was demonstrated by the example of medical diagnostics in. In this paper, uncertainty was understood as a statistical standard deviation, and a structural model of the formation of the system uncertainty of the result was developed by simulation. Then this problem was solved on the example of technical diagnostics of fuel equipment of diesel engines. In emphasized «there is no difference in the calculations, is there standard uncertainty as a measure of dispersion of a probability distribution of the input variable, or as a measure of dispersion of a probability distribution of error of this value». This approach is currently recommended and widely used in the system of objective quality control of food products and is enshrined in the standard - Hazard Analysis and Critical Control Point (Hazard analysis, risk assessment and determination of critical control points in the production process (management) [11]. In the Russian Federation, the standard GOST R 51705.1-2001 «Quality systems». Food quality management based on HACCP principles. This standard is based on the following principles: Principle 1 - conduct of risk analysis; principle 2 - determination of critical control points (ccts); principle 3 - establishment of critical limits; principle 4 - establishment of a control procedure; Principle 5 - establishment of corrective actions.

II. MATERIALS AND METHOD

Describe in detail the materials and methods used when conducting the study. The citations you make from different sources must be given and referenced in references.

*2.1 S*tochastic programmable control risk management principle

The statistical nature of the structural system agents of the control process generates decision-making risks, which are usually divided into the risk of the producer and the risk of the consumer [7]. Quantitative assessment and forecasting of these risks is impossible without the use of mathematical tools and computer technologies. There are a number of works that offer approaches to solving these problems [1,2]. The problem of quantitative assessment and forecasting of risks in the control and decision-making system is becoming extremely relevant in many areas of science and technology. Under the existing circumstances of total digitalization of the economy and social sphere, along with the effective solution of some local management tasks, unforeseen and undesirable challenges and problems appear. For example, in medicine, the introduction of diagnostic systems based on new computer technologies, the quality of medical care does not meet the expectations of the population. As follows from the analysis of the US media and special literature, about 45% of primary medical diagnoses are incorrect. With sufficient certainty, this can be attributed to the Republic of Kazakhstan. As it turned out, most errors in medicine are generated at the stage of analytical laboratory research and decision-making by a clinical specialist. As an example, the Internet presents the results of studies of the process of blood pressure control, obtained by the International Federation of Clinical Chemistry, which showed that the reliability of the most modern digital blood pressure monitoring devices is at best 60-70%. The question arises, what does reliability mean in this case, with what reference result these data were compared to make such a conclusion.

In medicine, most of the existing metrological standards, indicators and estimates are not acceptable. This is due to a number of reasons, and one of them is that if metrology is interested in the correctness of the measurement results in terms of their proximity to the actual value of the measured parameter, and the doctor is not interested in the measurement result itself, but in comparing the result with a group or individual "norm" of healthy individuals. The synergy of many factors generates decision-making risks in medical clinical practice, which are interpreted as the risk of the patient and the risk of the medical institution. Therefore, the use of formal methods based on system principles and approaches in laboratory and clinical studies will significantly increase the reliability of decision-making processes. The formalization of quantitative risk assessment of the patient and the person making clinical decisions will solve a very important problem, which consists in the fact that due to the adoption of a number of laws, the legal responsibility of medical personnel for the quality of medical services increases, there is an extreme need to objectively and evidently divide risks into two components: instrumental objective risks; subjective professional and competence risks. With the involvement of formal tools for describing the entire system process of risk formation, it becomes possible to make «transparent» the entire trajectory of the formation of the resulting decision-making error on the example of each control and measurement act and, thereby, reduce legal pressure on medical personnel. The introduction of expensive and supposedly accurate equipment also creates another economic problem-the optimal combination of cost and social efficiency of equipment.

It follows that control risks under conditions of statistical uncertainty of process control factors can be considered as assessments of the robustness of the system, and at the context level – as quality [12,13,14,15].

From this follows the purpose of the article, which is to model the processes of improving the quality of control of functional indicators of a multiparameter system.

To achieve the stated goal, it is necessary to solve the following tasks:

- develop a probabilistic model for quantifying the quality of control with non-deterministic tolerance standards based on decision-making risk criteria.
- develop software applications for evaluating and managing quality control.

The scientific novelty of the research consists in the development of models for quantitative assessment of instrumental risks in the environment of uncertainty of agents of the control and measurement algorithm.

Practical significance consists in the development of algorithms and software for risk management of control process agents.

The quality management of the control process of some complex control and measurement process is considered. As functional subprocesses, measurement, comparison of the measured value with standards, analysis, and decision-making are studied. In this problem, the control process is considered as a multi-agent system, where agents should be distinguished: agent – external environment; agent - object of control; agent-measurement process; agent-standard; agent-analysis, agent-decision-making system. In this context, «agents» combine such properties and concepts as: software and hardware technologically targeted entity; joint solution of a common problem by system aggregation; inter-agent information exchange; modularity; extensibility and adaptability; multi-approach in the process of formalizing the functionality of agents; system openness [16].

As noted, due to the fact that the measurement process technologically and at the formal level operates with uncertainties, control errors occur. Control errors are usually divided into errors called false and undetected failures (marriage Quantitatively, these errors are estimated by the corresponding probabilities, in this case, Rlb-the probability of a false marriage (false refusal) and Rnb-the probability of an undetected marriage (undetected refusal). The term «failure» is adopted from the theory of reliability. These probabilities are also given a pragmatic meaning of the risks of the work producer and the work consumer. Thus, the problem arises of developing formal models for risk assessment and forecasting in the function of statistical characteristics of the parameters of a multi-agent system. In a similar formulation, this problem was investigated in the works given above for the cases of deterministic standards. In this article we consider the case of nondeterministic specifications, which corresponds to a real multidisciplinary practice. Recently, there have been works in which it is also proposed to consider standards as random values, such as in ecology.

The problem of standards in medical practice, as in no other industry, is particularly acute, since we are talking about human health and life. Therefore, the study and quantitative prediction of the magnitude of instrumental and methodological errors with the involvement of mathematical apparatus is extremely relevant.

To develop mathematical models for estimating and predicting probable control errors in non-deterministic standards, a certain conditional diagnostic parameter Si was selected. The distribution density function of this parameter is f (S). The following are designated as standards: Sн - lower standard and Sв - upper standard and their statistical characteristics in the form of distribution laws:

$$\Theta_1(S_l)=\frac{1}{\sqrt{2\pi}\cdot\sigma_l}e^{-\frac{(S_l-S_{lm-s})^2}{2\sigma_{lH}^2}},\quad \Theta_2(S_t)=\frac{1}{\sqrt{2\pi}\cdot\sigma_t}e^{-\frac{(S_t-S_{lm-s})^2}{2\sigma_t^2}}$$

where sn, sb - standard deviations of the lower and upper standard values; Snsr, Svsr - the average values of the lower and upper standards. The average value of the Nsr is the center of the uncertainty region (scattering) of the lower standard. Similarly, the mean Hrv value is the center of the range of variations of the upper standard. The density function of the random error distribution of the measuring instrument is φ (y). It follows from this problem that the uncertainty parameters of the agent model under study are: the mean square deviations of the diagnostic parameter and the random measurement error; sn, sb - the mean square deviations of the standards. During the measurement, the following probable events are possible:

- true value of the parameter Si in the limits (N < Si < blower SB) and the measured value Is exceeds the upper limit or goes beyond the lower limit (Sm < N or Sm > blower SB). In this outcome, there is a case when the true value of the controlled parameter is in the permissible zone – «fit», and the «device» mistakenly fixes it outside the standard – «not fit». This case is called a «false failure», and the probability of its occurrence is the probability of a false failure of the Rlo;[17]

- the true value of the Si parameter is outside (Si < Sn or Si > Sb), and the measured Si value is within the tolerance (Sn < Siism < Sb). This case is called an undetected failure and the probability of its occurrence is the probability of an undetected failure of the Rno.

In this case, the composition is considered, when the distribution laws of the standards Sb and Sn are approximated by normal laws, and the controlled parameter S by the Weibull law. Weibull's law, as studies have shown, is not only one of the most common among the known laws, but also the most acceptable for modeling purposes. Weibull's law is a three-parameter law. Many laws, including the normal law, can be considered in some approximation as special cases of this law.

Formula for the total number of falsely rejected control and measurement solutions from the sample N

$$N\,fm=\sum_{i=1}^{k}N\int_{Li}^{Hi}\theta(S_B)dS_B\sum_{j=0}^{m}\left[\exp\left(-\frac{S_j^{\beta}}{\alpha}\right)-\exp\left(-\frac{S_{j+1}^{\beta}}{\alpha}\right)\right]\times\frac{1}{\sqrt{2\pi}}\int_{\frac{S_{Bi}-S_j}{\sigma_\varphi}}^{+3}e^{-\frac{z^2}{2}}dz$$

In the case of an undetected defect-failure, the number of control and measurement solutions from the sample N will be

$$N\,um=\sum_{i=1}^{k}N\int_{Li}^{Hi}\theta(S_B)dS_B\sum_{j=0}^{m}\left[\exp\left(-\frac{S_j^{\beta}}{\alpha}\right)-\exp\left(-\frac{S_{j+1}^{\beta}}{\alpha}\right)\right]\times\frac{1}{\sqrt{2\pi}}\int_{-3}^{\frac{S_j-S_{Bj}}{\sigma_\varphi}}e^{-\frac{z^2}{2}}dz$$

In order to verify the adequacy of theoretical assumptions to practical results, experimental statistical studies and a computer experiment using software were conducted. Figure 1 shows the screen form of the beginning of a computer experiment. The STATISTICA environment was used for statistical processing.[18,19]

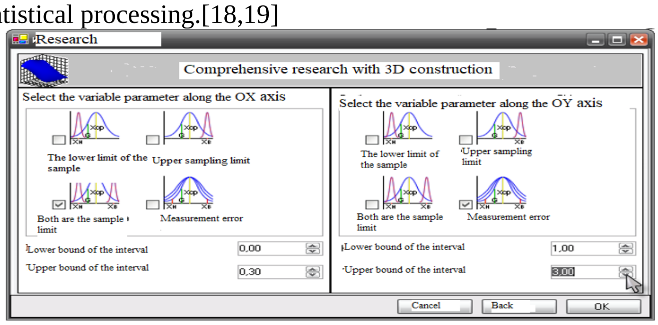

Fig. 1-Setting the parameters of a comprehensive study

III. RESULTS

The sample size included 200 observations for each age group. Figure 2 shows the results of modeling the non-deterministic case of standards, where Rnb are a function, and the relative uncertainty σφ / σs is the abscissa axis.

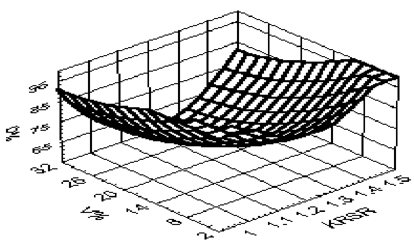

Fig. 2- The result of a computer experiment for non-deterministic standards (probability R_{lb})

As a result of the computer experiment, the following was found: the reliability of the control of systolic pressure in the age group up to 30 years was 73%; the reliability of control for the age group from 30 to 50 years was 61%; the reliability of control for the age group over 60 years old was 52% [20,21,22].

Control risks are the synergy of the following system agents: statistical distribution laws of the controlled parameter, measurement tools, standards, as well as the degree of uncertainty of the controlled parameter, measurement uncertainty and standard uncertainty. The control results are clearly nonlinear, which makes it impossible to predict the control results without the use of a mathematical apparatusThe quantitative assessment of control errors is determined not so much by the absolute values of σφ, σs, sn, sv, but to a greater extent by the ratios: σφ / σs; sn / σs; sv / σs. In these relations, as follows from Figure 2, the control errors are dominated by the normative value [23,24]. The presentation of the simulation results in 3D form allows you to reveal hidden, invisible in 2D constructions, patterns, for example, extreme areas of the minimum, as follows from Figure 2.

As a result of a computer experiment, it was also found that the probability of a false marriage (customer's risk) R_{lb} is most affected. With the value of measurement uncertainty σφ commensurate with the value of σs, the risk of the customer of services (consumer) can reach 45% [25].

III.DISCUSSION

To assess the adequacy of the theoretical premises to practical results, a computer experiment was carried out. The purpose of the experiment was to study the metrological indicators of the quality of the control process using the example of measuring blood pressure with a device - a tonometer. The choice of this device is not accidental, since this device can be considered the most common device both in everyday life and in professional clinical practice. Blood pressure control is receiving unprecedented attention on the Internet and in the media. Experimental studies were carried out on the basis of the regional cancer center. The studied patient population consisted of three age groups: the first group up to 20 years old, the second group from 30 to 50 years old and the third group from 50 to 70 years old.

V CONCLUSION

The results obtained are extremely important when choosing alternatives in the control paradigm, that is, what to give preference to in the current professional situation: the precision parameters of devices or regulatory regulations. The results obtained can be used as mathematical and ethodological support for automated control systems for organizational and technical systems.

ACKNOWLEDGMENT

The article was performed within the framework of the project of grant funding for fundamental and applied scientific research of young doctoral scientists under the project "Young Scientist" of the Ministry of Education and Science of the Republic of Kazakhstan for 2022-2024. IRN: AP14972524 - "Development of VLC technologies in driving unmanned vehicles".

Authors' Contributions

The authors' contributions to the paper are equal.

Statement of Conflicts of Interest

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

The authors declare that this study complies with Research and Publication Ethics

REFERENCES

[1] Makenov A. A., Mashekenova A. H., Radjabov R. C. Quality assessment of multi-parameter control of vehicle complex systems efficiency. – Almaty, 2020. Volume 2, № 2(440). – pp. 96 ‑ 102.

[2] International Conference on Simulation and Modeling Methodologiens, Applications. Quantitave Evaluatin of Accuracy of Digital Microscope System for Automated Petrographic Analysis/ Shvets O. - Vienna, Austria: p.559-566.

[3] Jacques Ferber, Olivier Gutknecht, Fabien Michel From Agents to Organizations: an Organizational View of Multi-Agent Systems [Electronic resource] Access mode:: http://www.lirmm.fr/~fmichel/publi/pdfs/ferber04ocmas.pdf

[4]] Jacques Ferber, Olivier Gutknecht, Fabien Michel The MADKIT Agent Platform Architecture [Electronic resource] Access mode: http://www.madkit.net/documents/others/MadkitTechnicalReport.pdf

[5] Muhammad Sohail MADKIT (Multi-Agent Development Kit) : A generic multi-agent platform [Electronic resource] Access mode: http://perso.limsi.fr/jps/enseignement/examsma/2005/1.plateformes_2/SOHAIL/SOHAIL.htm

[6] EUROCHEM/CITAC Guide «Quantifying Uncertainty in Analytical Measu-rements», Second Ed. 2002. – 141 с.

[7] Modarres M., Kaminsky M.P., Krivtsov V. Reliability Engineering and Risk Theory: A Practical Guide. CRC Press, Taylor and Francis Group, 2016. 522 p.

[8] *FLEXChip Signal Processor (MC68175/D)*, Motorola, 1996.

[9] Guide to the Expression of Uncertainty in Measurement Keith D. Mc. Croan MARLAP Uncertainty Workshop October 24, 2005 Stateline, Nevada

[10] Winterfeldt D. von and G.W.Fischer Multiattribute utility theory: Models and assessment procedures//D.Wendt and C Vlek (Eds.). Utility, probability and human decision making. Amsterdam: Reidel, № 1986.

[11] [Electronic resource] Access mode: eng-rus-economy-dict....

[12] Doyle J.C, Stein G. Multivariable Feedback Design: Consepts for a Classical I Modern Synthesis II IEEE Trans. Auto. Control. 1981. Vol. AC-26. N1.

[13] "Robust Industrial Control Systems" - Grimble Michael J. - https://doi.org/10.3311/PPme.9312

[14] [14] Zhou K., Doyle J.C. Essentials of Robust Control. – Prentice Hall, Upper Saddle River, New Jersey,1998.

[15] Wang F., Tang C., Huang B. Multivariable Robust Control for a Red–Green–Blue LED Lighting System // IEEE Transactions on Power Electronics. – 2010. – vol. 25, №2. – pp. 417-428.

[16] Alibekkyzy K, Wojcik W, Vyacheslav K, Belginova S. Robust data transfer paradigm based on VLC technologies. Journal of Theoretical and Applied Information Technology. 2021 Little Lion Scientific. 15th February 2021. Vol.99. No 3.

[17] Wójcik W., Karmenova M., Smailova S. et al. Development of data-mining technique for seismic vulnerability assessment // Journal of

Electronics and Telecommunications. – 2021. – Vol. 67, Issue 2. – P. 261-266.

[18] Kornev, V.A., Makenov, A.A., Mashekenova, A.H., Radjabov, R.C. Quality assessment of multi-parameter control of vehicle complex systems efficiency//News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciencesthis link is disabled, 2020, 2(440),pp. 96–102

[19] Baklanova, O.E., Kornev, V.A., Shvets, O.Ya. Quantitative evaluation of accuracy of digital microscope system for automated petrographic analysis//SIMULTECH 2014 - Proceedings of the 4th International Conference on Simulation and Modeling Methodologies, Technologies and Applications, 2014

[20] Karymsakova, I., Denissova, N., Kumargazhanova, S., Krak, I. Robotic plasma spraying system for implants of complex structure: 3d model and motion planning//International Journal of Computingthis link is disabled, 2020, 19(2), стр. 224–232

[21] Karymsakova, I.B., Krak, I.V., Denissova, N.F. Criteria for implants classification for coating implants using plasma spraying by robotic complex//Eurasian Journal of Mathematical and Computer Applicationsthis link is disabled, 2017, 5(3), стр. 44–5

[22] Bedebayeva, M., Kadirbayeva, R., Suleimenova, L., Zhetpisbayeva, G.O., Nurmukhanbetova, G. Methods of teaching school informatics in English based on blended learning technology//Cypriot Journal of Educational Sciencesthis link is disabled, 2021, 16(6), стр. 3305–3316

[23] Adikanova, S., Malgazhdarov, Y.A., Madiyarov, M.N., Temirbekov, N.M. Probabilistic statistical modeling of air pollution from vehicles//AIP Conference Proceedingsthis link is disabled, 2017, 1880, 060017

[24] Shvets, O., Bugubayeva, A., Rakhmetullina, S., Wojcik, W. Development of intelligent information system of assessing the negative impact of industrial emissions on the public health//Journal of Theoretical and Applied Information Technologythis link is disabled, 2021, 99(15), стр. 3736–3752

[25] Oralbekova, Z., Khassenova, Z., Mynbayeva, B., Zhartybayeva, M., Iskakov, K. Information system for monitoring of urban air pollution by heavy metals//Indonesian Journal of Electrical Engineering and Computer Sciencethis link is disabled, 2021, 22(3), стр. 1590–1600