Odesa Polytechnic National University, Kiev National University, T. Shevchenko, Kharkov National University of Radio Electronics, National Aviation University, Odesa National University, I.I. Mechnikov, Sumy State University, Admiral Makarov National University of Shipbuilding, Lodz Technical University, Azerbaijan State Oil Industry University, Anhalt University of Applied Sciences, Caten, Germany,

CEUR

MATERIALS

OF THE XII INTERNATIONAL SCIENTIFIC-PRACTICAL CONFERENCE

«Information Control Systems and Technologies»

(ICST- ODESA – 2024)

23th – 25th September, 2024

Odesa 2024

УДК 004:37:001:62
І74

І74 **ІНФОРМАЦІЙНІ** УПРАВЛЯЮЧІ СИСТЕМИ І ТЕХНОЛОГІЇ (ІУСТ-ОДЕСА-2024) : матеріали XII Міжнародної науково-практичної конференціїі (23-25 вересень 2024 р. Одеса) / вип. ред. В.В. Вичужанін. – Одеса : Видавничий дім "Гельветика", 2024. – 334 с.
ISBN 978-617-554-315-3

Збірник містить Матеріали, прийняті оргкомітетом до участі в Міжнародній науково - практичній конференції «ІНФОРМАЦІЙНІ УПРАВЛЯЮЧІ СИСТЕМИ І ТЕХНОЛОГІЇ» (ІУСТ-ОДЕСА-2024).

Наведені матеріали конференції охоплюють основні напрямки розвитку в області інформацйіонних систем управління; інтелектуальних систем і аналізу данних; моделювання та розробки програм.

УДК 004:37:001:62

ISBN 978-617-554-315-3

SECTION 3. MODELING AND SOFTWARE ENGINEERING

UDC 519.85

OPTIMIZATION GEOMETRIC DESIGN IN INTELLIGENT SYSTEMS FOR ENSURING SAFETY

Dr.Sci. A. Chuhai[1,2][0000-0002-4079-5632], Dr.Sci. G. Yaskov[1,3] [0000-0002-1476-1818], Dr.Sci. O. Starkova[2][0000-0002-9034-8830]

[1] Anatolii Pidhornyi Institute of Mechanical Engineering Problems of the National Academy of Sciences of Ukraine, Ukraine, [2] Simon Kuznets Kharkiv National University of Economics, Ukraine,

[3] Kharkiv National University of Radio Electronics, Ukraine

EMAIL: [1]chugay@ipmach.kharkov.ua, [3]yaskov@ukr.net, [2]olha.starkova@hneu.net

ОПТИМІЗАЦІЯ ГЕОМЕТРИЧНОГО ПРОЕКТУ В ІНТЕЛЕКТУАЛЬНИХ СИСТЕМАХ ДЛЯ ЗАБЕЗПЕЧЕННЯ БЕЗПЕКИ

Dr.Sci. А. Чугай[1,2], Dr.Sci. Г. Яськов[1,3], Dr.Sci. О. Старкова[2]

[1]Інститут проблем машинобудування імені Анатолія Підгорного НАН України, Україна,

[2]Харківський національний економічний університет імені Симона Кузнеця, Україна,

[3]Харківський національний університет радіоелектроніки, Україна

Abstract. *Packing optimization problems have diverse real-world applications, particularly in safety systems across various industries. A critical application is the safe storage of spent nuclear fuel (SNF), where optimizing the placement of congruent circles within a multiconnected domain, under technological constraints, is essential. We developed a mathematical model for this problem, using phi-function techniques to represent relationships between geometric objects. This approach reduces the problem to a nonlinear programming task, offering an effective solution framework.* ***Keywords:*** *Intelligent systems for ensuring safety, optimization packing problem, mathematical modeling, phi-function, non-linear programing.*

Анотація. *Проблеми оптимізації упаковки мають різні реальні застосування, зокрема в системах безпеки в різних галузях. Важливим застосуванням є безпечне зберігання відпрацьованого ядерного палива (ВЯП), де оптимізація розміщення конгруентних кіл у багатозв'язній області за технологічних обмежень є важливою. Ми розробили математичну модель для цієї проблеми, використовуючи методи фі-функції для представлення зв'язків між геометричними об'єктами. Цей підхід зводить проблему до завдання нелінійного програмування, пропонуючи ефективну структуру рішення.*

Ключові слова: *інтелектуальні системи забезпечення безпеки, оптимізаційна задача пакування, математичне моделювання, phi-функція, нелінійне програмування.*

In today's advanced world, safety systems are essential for ensuring the secure and reliable operation of various technologies, protecting people and infrastructure from hazards [1,2]. They are especially critical in industries with catastrophic failure risks, such as nuclear power, chemical manufacturing, and aviation, where they are designed to prevent and mitigate accidents [3]. Safety systems are crucial not only for preventing threats but also for detecting and responding to incidents. With continuous monitoring and advanced analytics, these systems quickly identify issues and initiate responses, managing risks before they escalate. A key application is in storing hazardous materials like flammable liquids and gases. Safe storage involves more than containment; it requires minimizing accident risks and ensuring rapid response. The challenge includes both physical containment and strategic container placement, considering factors like substance type, container characteristics, and spatial arrangement to reduce hazards and improve response. The primary objective of this study is to develop a comprehensive mathematical model to address the optimal placement of containers, along with devising effective methods for finding a solution. This paper emphasizes the creation of an intelligent system designed to determine the optimal arrangement of containers within a storage area. By casting the problem as an optimization challenge, where the problem is to position congruent circles within a multiconnected domain while strictly adhering to technological and safety constraints, we tackle a critical issue relevant to nuclear, thermal, and chemical safety. The system employs advanced mathematical modeling techniques, particularly the phi-function method, which effectively represents the geometric relationships between objects. This approach simplifies the problem by converting it into a nonlinear programming problem, making it more tractable for computational algorithms. The proposed intelligent system integrates these mathematical models and algorithms to deliver a robust solution for safe and efficient storage. By highlighting the key features and benefits of the system, the paper demonstrates its potential to significantly enhance operational safety and storage efficiency in various industrial facilities.

The goal of geometric design optimization is to find the optimal spatial arrangement of geometric entities within a container, adhering to all rules and constraints, to achieve the best possible outcome. This emphasizes precision and efficiency in container design and placement, maximizing safety and operational effectiveness. To effectively frame the problem of container placement within the context of geometric design optimization and safety systems, it is crucial to analytically define several key elements of the system: the spatial form of the placement area, the spatial form of the entities to be placed within the placement area, the technological conditions for positioning a specified set of entities within the placement zone, the optimization criterion. The technological restrictions governing the placement of a given set of objects within the designated area can be classified into two primary types of constraints. Problem statement: determine the vector that ensures the placement of the maximum number of circles from a given set within the designated area while adhering to the specified technological constraints. To address this problem, a multi-stage methodology is proposed for packing containers, taking into account the defined technological constraints. At each stage, nonlinear optimization techniques and advanced NLP (Nonlinear Programming) solvers are employed [4,5]. The proposed methodology hinges on a multi-stage solution approach. In order to optimally fill a given area under the imposed constraints, the first stage involves solving an optimization problem aimed at placing the maximum number of containers within a complex area that includes restricted zones. To ensure safety from heightened thermal and ionizing levels, and to achieve a uniform distribution of ionizing radiation within the storage area for spent nuclear fuel, constraints are imposed on the minimum allowable distances between groups of containers. At this stage, a modification of the feasible direction method, incorporating an active set strategy, is developed for local optimization. For global optimization, a sequential statistical optimization method is designed, ensuring that the overall solution effectively balances safety requirements and maximizes the utilization of the available space. In the second stage, to ensure proper servicing conditions for the containers within the area, the focus shifts to addressing the placement of clusters of various geometric shapes. These clusters must be arranged to maintain specific distances that allow the passage of service equipment. To solve this problem, a nonlinear optimization method based on the interior point method is employed, enhanced by a special decomposition algorithm. This approach effectively handles the complex spatial relationships and distance constraints necessary for safe and efficient servicing. In the third stage, the total ionizing field of the area is calculated. If the resulting ionizing field does not meet the established safety and operational criteria, the problems from the first two stages are revisited iteratively. This iterative process continues until the desired field parameters are achieved, ensuring that both the spatial configuration and the safety requirements are fully optimized. To address the problem in the first stage, a systematic strategy has been developed incorporating the following methodological sequence. Constructing starting points: the approach utilizes the regular placements method and the block coordinate descent method to generate starting configurations. These methods facilitate the systematic arrangement of congruent three-dimensional geometric objects within the feasible domain. Local extrema search: a refined method of feasible directions, augmented with an active set strategy applied to subdomains, is employed to locate local extrema. This approach is designed to efficiently navigate the local landscape of the objective function and identify potential optimal solutions within specific regions. Approaching global extrema: a modified narrowing neighborhoods method is used to refine the search for global extrema. This technique systematically reduces the search area to focus on finding the global optimal solution. The primary strategy involves optimizing the objective function defined over a set of permutations. For an effective global extremum search, the objective function must exhibit quasi-separability and possess multiple extrema. The distribution of these local extrema should follow a pattern that can be statistically characterized, treating each extremum as an outcome of a random variable. In constructing starting points within the feasible domain, methods are employed that involve sequentially placing three-dimensional geometric objects. This process is facilitated by either the block coordinate descent method or the regular placements method, both of which focus on arranging congruent three-dimensional geometric objects. The phi-function method is utilized for formulating the mathematical model, allowing the application of contemporary nonlinear optimization techniques across all stages of the problem-solving process. This includes initial point generation, local extremum search, and the exploration of local extrema, leveraging the phi-function method’s capability to represent complex geometric relationships.

References

[1] Bates D. W., Gawande A. A., Improving Safety with Information Technology. New England Journal of Medicine. 2013. Vol. 348. P. 2526–2534. Doi: 10.1056/NEJMsa020847.

[2] Benintendi R., Rodriguez Guio A. D., Marsh S. C. A risk-based approach to safety distance determination in the process industry. 2014. Symposium Ser. No. 159. URL : https://api.semanticscholar.org/CorpusID:219572699.

[3] Fischer M., Klingel L., Lechler A., Verl A., Neubauer M. Dynamic Safety Distance Determination for Human Robot Coexistence in Industrial Applications. Advances in Automotive Production Technology – Towards Software-Defined Manufacturing and Resilient Supply Chains: monograph / Kiefl N., Wulle F., Ackermann C., Holder D. (eds.); SCAP 2022, ARENA2036. Springer, Cham, 2023. Doi : 0.1007/978-3-031-27933-1_4.

[4] Romanova T., Stoyan Yu., Pankratov A., Litvinchev I., Kravchenko, Z. Duryagina, O. Melashenko, A. Chugai. Optimized packing soft ellipses. Human-Assisted Intelligent Computing : Modelling, simulations and applications : monograph. IOP Publishing, 2023. P. 9.1–9.14. Doi: 10.1088/978-0-7503-4801-0ch9.

[5] Yaskov G., Chugay A. Packing equal spheres by means of the block coordinate descent method. The Third International Workshop on Computer Modeling and Intelligent Systems (CMIS-2020) : Proc. of CMIS-2020, Zaporizhzhia, Ukraine, April 27 – May 1, 2020. P. 156–158. Doi : 10.32782/cmis/2608-13.

UDC 336.71

APPLICATION OF GARCH MODELS IN THE ASSESSMENT AND FORECASTING OF CREDIT MARKET VARIABLES

Dr.Sci. O. Mandych[1][0000-0002-4375-2208], Ph.D. T.Staverska[1][0000-0001-8417-2982], Ph.D. O. Horokh[1][0000-0003-1490-9074], Ph.D. S. Brik[2][0000-0002-5411-4885], Ph.D. V. Makohon[1][0000-0002-5967-1760]
[1]State Biotechnological University, Ukraine
[2]National Technical University "Kharkiv Polytechnic Institute", Ukraine
EMAIL: ol.mandych@gmail.com, staverskaya@gmail.com, gorohsasha82@gmail.com, svetsvb@gmail.com, wimak.ua@gmail.com

ЗАСТОСУВАННЯ GARCH МОДЕЛЕЙ ПРИ ОЦІНЦІ ТА ПРОГНОЗУВАННІ VAR КРЕДИТНОГО РИНКУ

Dr.Sci. О. Мандич[1], Ph.D. Т.Ставерська[1], Ph.D. О. Горох[1], Ph.D. С. Брік[2], Ph.D. В. Макогон[1]
[1]Державний біотехнологічний університет, Україна,
[2]Національний технічний університет "Харківськії політехнічний інститут", Україна