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Information and Communication Technologies and Sustainable Development

Advanced Approaches and Innovations in Up-to-Date Networks and Systems

Springer

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Preface

This volume is a collection of the most important research results in the fields of information and communication technologies, geoinformation systems, and mathematical modeling, prepared by various groups of researchers from Ukraine in cooperation with scientists from different countries. The authors of the chapters' collection present in-depth and extended results of research in their scientific fields.

The volume is divided into **four parts**, each focusing on different aspects of research**:**

Part I: Sustainable Development (Analysis of Problems and Technological Factors) addresses significant problems related to sustainable development in the global information space. It analyzes challenges and technological factors concerning resource accessibility and the advancements of new-generation mobile communication systems and software-defined networks.

Part II: Trends in the Development of Information and Communication Technologies and Systems comprises original works covering various issues in the development of communication networks in automated special-purpose systems. It also delves into the practical implementation of the Internet of things (IoT), the fundamentals of information and analytical activities, ontological models in information systems, energy-efficient technologies for data center workload processing, and the implementation of new multidimensional cryptosystems.

Part III: Geoinformation Systems and Remote Sensing of the Earth presents topical articles showcasing effective technological solutions for cloud platforms and earth remote sensing data processing technologies.

Part IV: Mathematical Modeling in Applied Problems includes relevant papers demonstrating effective technological solutions applicable to novel radio electronics, communication, and distributed information systems. It provides specific examples using artificial neural networks, applied optimization problems for a group of unmanned aerial vehicles' movement, and the study of limit trajectories of electron beams for cloud computing implementation.

For the convenience of the readers, we briefly summarize the contents of the chapters accepted.

Part I Sustainable Development (Analysis of Problems and Technological Factors).

The first chapter, presented by the author **P. Vorobiyenko** ***Sustainable Development in the Global Information Space,*** nine root causes of threats to humanity are identified. These include insufficient efforts in fostering a positive human nature, imperfections in election systems for state authorities, lack of legal acts to influence state leadership violating international law (excluding war defeat), unbalanced governance in addressing national and international issues, excessive focus on human rights without considering responsibilities, delayed reactions from the global community to emerging threats, disregard for new patterns in economic science and practice, the presence of

highly corrupted countries forming unstable centers globally, and inadequate motivation of some states in executing sustainable development goals. The chapter highlights the significant role of information and communication technologies (ICT) in achieving sustainable development. ICT's contributions include developing new learning technologies, modernizing and creating new industries, promoting societal democratization, accelerating scientific research, and enhancing people's lives. The concept of sustainable development is grounded on principles aimed at addressing the identified root causes of threats. Additionally, the chapter proposes various mechanisms for achieving sustainable development in the global information space.

The chapter ***Enhancing Resource Availability: Indicators and Strategies for Optimizing the Kubernetes Network*** by **O. Romanov, V. Mankivskyi, L. Globa, M. Skulysh, A. Romanov** focuses on the challenge of improving software network systems' efficiency and flexibility while reducing service implementation time. The focus is on implementing container orchestration systems with network virtualization functions in Kubernetes architecture. The article discusses network load service models within Kubernetes and explores ways to ensure scalability, high fault tolerance, and different deployment scenarios. The study proposes a method for calculating Kubernetes network availability and evaluates two traffic distribution scenarios between Pods. Experimental studies in an Amazon private cloud-based Kubernetes cluster demonstrate the effectiveness of the proposed solutions in achieving the required availability indicators with effective service management algorithms and excess computing power.

The chapter presented by **K. Karpov, D. Kachan, and E. Siemens** ***Enhancing Application Layer Multicast using Multi-Objective Optimization Techniques*** introduces a novel approach to optimize application layer multicast (ALM) using the non-dominated sorting genetic algorithm-II (NSGA-II). The method focuses on multiple network metrics such as round-trip time (RTT) and available bandwidth. By incorporating the capabilities of the RMDT protocol, the proposed approach optimizes the multicast tree structure for efficient data dissemination across the network. The use of NSGA-II enables simultaneous optimization of multiple objectives, providing adaptability and efficiency in dynamic network conditions. Extensive experiments and simulations validate the effectiveness of this approach in minimizing multicast tree cost and maximizing network resource utilization for large-scale applications.

The chapter ***Possible ways of determining the characteristics of network traffic for identification of required external connection line rate for a specific object*** by **V. Kaptur and R. Tsaryov,** focuses on providing broadband Internet access, and the key challenge is determining the required external connection line rate for a specific object. There are many different methods to calculate necessary bandwidth of external connection line, but majority of these methods are based on the using of the network traffic characteristics. To calculate the required external line rate of such external channels, it is necessary to identify the number of simultaneous sessions that could be served by the channel without decreasing quality of experience (QoE) level. At the same time, it is also necessary to identify the level of the workload of each session on the channel, considering that for the different services, the length of the sessions (in seconds), and data transfer rates are different. This paper considers approach of calculating the required external line rate that uses traffic profiles and possible ways of determining the characteristics of

network traffic that are used to calculate the required bandwidth. The approach has been validated in ITU regional broadband initiatives, leading to the creation of an automated tool called ITU bandwidth calculator for calculating the required external line rate.

The chapter ***A Research Method of Software-Defined Networks Asymptotic Properties with Markov Intrusion of Randomness*** by **S. Degtyar, O. Kopiika and Y. Shusharin** focuses on the asymptotic properties of software-defined networks (SDNs) with Markov intrusion of randomness. It explores the Network services platform's role in SDNs, particularly in providing telecommunication services. The SDN operation process is modeled using queuing systems to assess network parameters, considering the stochastic nature of service requirements. Stochastic methods are developed to study different classes of random processes that accurately describe phenomena in SDNs. These classes include processes with discrete interference of events that impact quality of service parameters. The chapter extends classical renewal theory to the Markov renewal equation, providing a proven Markov renewal theorem for studying the limiting behavior of Markov and related processes in SDNs. This analytical tool allows for studying transient phenomena, such as the asymptotic behavior of various processes in SDNs.

The chapter presented by **S. Zaitsev, N. Sokorynska, V. Prystupa and L. Zaitseva** ***Mathematical Model for Evaluation of Interference Dispersion for 5G Mobile Communication Systems*** introduces an approach at improving the efficiency of functioning of wireless networks of mobile communication 5G. A proposed mathematical model for iterative estimation of the dispersion of white Gaussian noise interference in wireless 5G data transmission systems. The estimation of the interference dispersion is carried out by analyzing the results of calculating the logarithmic ratios of the likelihood functions during iterative decoding of multi-component turbo codes. The difference between the developed mathematical model and the existing ones, which determines its novelty, is that the evaluation of the interference dispersion is carried out by analyzing the results of calculating the logarithmic ratios of the likelihood functions when decoding multi-component turbo codes, and taking into account the values obtained during iterative decoding. To evaluate the effectiveness of the proposed model, a simulation model was developed, which allows you to evaluate the reliability of wireless data transmission with a module for evaluating the dispersion of interference. The use of a mathematical model allows to reduce the error of channel state estimation and increases the reliability of information in wireless data transmission systems. The improvement in characteristics occurs when comparing channel estimation without knowledge of interference dispersion data, with dispersion estimation using two- and three-component decoding (up to 0.7 dB for different values of the decoding bit error probability).

In the chapter ***Method Radio Resource Allocation in Cognitive Radio Network*** by **Y. Koliadenko, M. Moskalets, V. Badieiev, R. Savchenko**, the authors explore cognitive radio as a capability-learning radio that can adapt its parameters based on knowledge of the radio environment. They propose a game-theoretic model using a Markov chain to analyze interactions within the network. However, the current resource frequency distribution methods may not optimize resource allocation. To address this, they present a method for optimal frequency resource allocation based on the criterion of guaranteed communication quality. The proposed method shows promising results in

enhancing communication reliability, achieving a probability of correct signal reception of 0.01.

Part II Trends in the Development of Information and Communication Technologies and Systems.

In chapter ***Features of Message Transport Service in Automated Special-Purpose Systems*** **by S. Dovgyi, O. Kopiika, O. Kozlov and A. Lytvynenko**, the authors present structural diagrams of message exchange for different versions of radio network building for automated special-purpose systems and the problem of optimizing the message transport service is solved. The message exchange service is considered in the context of: one workstation, one domain and interconnect between domains. A control algorithm is defined for the selection of message transmitting optimal route between network nodes that provide minimal transferring time between subscribers. Solutions to dynamic programming problems with additive and multiplicative effect functions are presented. A numerical example of best-route algorithm is considered. It was determined that dynamic information flow control algorithms are most effective when taking into account both, the probability of the radio communication lines' capability as well as their actual state in order to create the shortest path with minimal transferring time or sufficient throughput route between subscribers.

In chapter ***QoS-Aware Adaptation Traffic Engineering Solution for Multipath Routing in Communication Network*** by **O. Lemeshko, O. Yeremenko, M. Yevdokymenko, V. Lemeshko and M. Persikov**, the authors propose an approach to ensuring the quality of service (QoS) in communication networks through traffic management. It has been established that routing protocols, which implement load balancing based on traffic engineering technology, effectively ensure QoS based on network performance indicators (bandwidth, delay, jitter, packet loss). However, well-known theoretical and protocol routing solutions in this direction, such as DiffServ-aware traffic engineering (DS-TE), provide traffic differentiation only with link bandwidth distribution and reservation, significantly complicating the router's algorithmic software. Therefore, the work proposes a QoS-aware adaptation traffic engineering solution for multipath routing in communication networks. Within the framework of the proposed solution, the mathematical model of traffic engineering multipath routing is modified. Here the load balancing in the network is optimized in such a way that more priority flows are routed through links that are less loaded concerning those links through which packets of lower priority flows are transmitted. First, this was achieved using the linear optimality criterion applied to minimize each link utilization separately and the upper bound of the network link utilization in general during routing. Second, the conditions for balanced loading of network links were modified, which considered the priorities of the packet flows transmitted by them. The adequacy and workability of the proposed solution have been demonstrated on numerous calculated examples, and its properties have been confirmed in terms of providing differentiated quality of service only through routing and load balancing by disjoint paths.

S. Trendov, E. Stoilkovska and E. Siemens (*Impact of LoRaWAN Operational Parameters on Energy Efficiency and Ways to Improve it*) investigate the energy efficiency of long-range wide area network (LoRaWAN) technology in the context of the increasing number of Internet of things (IoT) devices and diverse IoT applications.

They aim to identify limitations and areas for improvement in energy conservation. The researchers conduct detailed experiments using two LoRaWAN end devices and a gateway, analyzing various network parameters such as signal strength, uplink, downlink, sleep periods, and round-trip time in different scenarios. Tests are conducted in both urban and free-field environments to determine the maximum stable communication range between an end device and a gateway. Special focus is placed on the power consumption and battery life of the end device when utilizing LoRaWAN technology. The study examines the impact of transmission power, packet size, and spreading factor on the microcontroller's processing power and the transceiver's power requirements, affecting the battery life of the end device. Furthermore, the researchers discuss methods and ideas for enhancing battery life in LoRaWAN-powered end devices. By highlighting the potential weak points, this study contributes valuable insights to improve energy efficiency and extend battery life for IoT devices operating with LoRaWAN technology.

The chapter ***Notation System for Comparing and Synthesis of Intelligent Key Phrase Extraction Methods for Ontological Models in Information Systems*** by **K. Bondalietov and V. Mokin** is dedicated to the problem of extracting keywords from English texts. This task is essential for building ontological models of information retrieval systems, comparing different texts, and other similar tasks. A comparative analysis of well-known methods for extracting both individual words and their combinations has been conducted. Indeed, the most valuable keywords are multi-word ones, as several such words allow for a complete description of both the uniqueness of the text and its correspondence to broader thematic categories. A new notation system and graphical representation of the main stages of each keyword extraction method have been developed. Using this system, notation and graphic visualization of all the most popular methods have been carried out. The advantages and disadvantages of all considered methods have been analyzed. Using the developed notation, several new methods have been proposed, which possess the advantages of known methods but lack their disadvantages. The effectiveness of the known and proposed methods has been tested on a real example of texts from a monograph by one of the authors, which was published with the funding of a grant from the Swedish government's SIDA on the topic of water resource management in a river basin. The analysis showed that the newly developed methods are more effective, proving the scientific and practical value of the proposed methods notation and constructing new methods based on it.

In chapter ***IT platform for the formation of digital duplicates for museum exhibits by*** **A. Honchar, S. Dovgyi and A. Lytvynenko**, the authors propose the creation of new models, methods and means of forming, processing, and displaying digital images of historical and cultural heritage preservation objects in a narrative format, which are able to provide the user with the opportunity to use them in the form of consolidated interactive knowledge systems. The transdisciplinary format of narrative discourse is considered as an operational platform for forming a cognitive-communication scenario of interaction with virtual museum exhibits consolidated with network information resources. An ontological model of transdisciplinary consolidation of 3D panoramas with network information resources and knowledge systems of meaningful display of historical and cultural heritage based on transdisciplinary properties of narrative discourse has been built. The main idea of the approach is the transdisciplinary consolidation of network

information resources and knowledge systems in the environment of virtual museum expositions. The approach described in this article was tested on the "Museum Portal" IT platform to support user interaction in the process of researching historical and cultural events, facts and phenomena in the format of a single scientific and educational environment "Museum Planet." The approach makes it possible to achieve the improvement of user interaction with virtual museum exhibits consolidated with thematically defined network information resources.

The chapter ***The modified approach to Internet of Things data transmission based on a combined neural network autoencoder*** by **L. Globa, V. Kurdecha and S. Ushakov** focuses on the problem of processing and efficiently transmitting data in real-time mode for Internet of things (IoT) systems. There are a lot of theoretical and practical researches in this direction but the critical remains data processing and transmission particular in real-time mode. This paper addresses the challenges of data compression and transmission in the networks of the IoT, using DeepZip—a neural network-based model, distributed systems, and edge computing methodologies. Detailed research has been conducted on data compression through DeepZip and its application to IoT networks. The modified method of data compression in the IoT network using algorithms of a trained neural network and edge computing technologies is proposed, which combines the advantages of recurrent neural networks with the capabilities of the classical compression method, which made it possible to reduce the volume of data transmitted by the network. Practical data derived from real-world IoT networks have been employed to demonstrate the efficiency of these approaches. The data compression and transmission methodologies were optimized with DeepZip, distributed systems, and edge computing. This improves the operational efficiency of IoT networks. As such, this approach enables engineers to design and implement IoT systems with improved data handling capabilities. Application of the modified method made it possible to optimize data transfer and reduce network load. Software developed on the basis of a modified method is used in Internet of things networks to process large volumes of data, including in real time.

In ***Study of energy-efficient technologies for workload processing in data centers*** by **L. Globa, A. Raichuk and N. Prokopets**, the authors present the approach to energy-efficient data processing in telecom data centers with support for all QoS requirements. The trend of software implementation of hardware functions in modern communication networks has contributed to the development of technologies and concepts such as NFV, SDN, network slicing, edge computing, bDDN. Implementing these concepts requires significant computational effort, resulting in a load on data centers and significant energy consumption for processing this load. The analysis of publications with proposals for increasing the energy efficiency of workload processing in distributed data centers made it possible to determine the advantages of a number of approaches that provide an increase in the energy efficiency of load processing in communication networks. But all these approaches do not provide a simultaneous increase in energy efficiency and productivity of load processing while meeting SLA requirements. To ensure energy-efficient data processing and improve its processing productivity, while maintaining the quality of SLA requirements, an approach was proposed, the essence of which is to take into account the daily load and allocate data processing resources in such a way as to minimize energy consumption and not lose productivity during processing. The study

of the proposed approach revealed its energy efficiency gain of 9.953% in comparison with Backfill and 26.382% energy efficiency gain in comparison with the Round Robin input load scheduling algorithm.

I. Strelkovskaya, I. Solovskaya and J. Strelkovska (*Comparison of methods for determining user coordinates in a Wi-Fi/Indoor network*) deals with an important task of determining the coordinates of the user's location indoors in conditions of high user concentration and difficulties in radio signal propagation. The technological development of radio access networks determines the rapid introduction of LBS services and applications that use the user's current location. LBS services and applications are quite critical to the accuracy of local location determination, so an important task is to determine the coordinates of the user's location indoors in conditions of high user concentration and difficulties in radio signal propagation. For radio access technologies, such as Wi-Fi (IEEE 802.11n/ac/ad) and BLE (IEEE 802.15.1), the fingerprinting method is considered, and it is established that the use of this method allows for an increase the positioning accuracy. The results of the accuracy of user location in a Wi-Fi/indoor network based on the fingerprinting method are compared using various methods for determining the user's location, such as the k-nearest neighbors (k-NN) method, the weighted k-WNN method, the probabilistic Bayesian method, and the complex spline approximation based on the quadratic complex spline. According to the criterion of the average absolute error of the MAE, it was found that the use of a complex spline approximation based on a quadratic complex spline improves the accuracy of user positioning in the Wi-Fi/Indoor network, thereby providing LWS-oriented services to users indoors.

This chapter ***Transdisciplinary principles of consolidation*** **by O. Stryzhak, V. Gorborukov, S. Dovgyi, V. Prykhodniuk, V. Shapovalov and Y. Shapovalov** describes the concept of implementing the consolidated use of network narratives based on the ontological representation of their structures. Concept contexts of ontologies are represented as terms with holes in Lambda calculus notation. These ontologies are presented in the format of Böhm's trees. Further, on their basis, reduction chains are formed, which are interpreted as a narrative discourse. Thus, the narrative discourse determines the technological basis of consolidation, as a cognitive and communicative act of intercontextual interaction of the narratives used. On the basis of a transdisciplinary approach to the consolidation of network narratives, a portal for the study of historical and cultural heritage was formed. The tools that were created according to the given concept ensured the consolidated use of various forms of display of museum exhibits and corresponding historical narratives as passive knowledge systems. Based on the transdisciplinary principles of consolidation of network narratives, the user is provided with mechanisms for their full-scale linking based on the semantic proximity of their detected contexts. This implements the processes of automatic formation of fully connected context-oriented information environments based on a set of concepts operated by the user.

The purpose of chapter ***Network Monitoring Index in the Information Security Management System of Critical Information Infrastructure Objects*** **(M. Khudyntsev, O. Lebid, M. Bychenok, A. Zhylin and A. Davydiuk)** is the analysis of existing indexes and indicators of cybersecurity and the network monitoring (NMI) formation based on this analysis. The authors analyzed fifteen existing cybersecurity indexes that contain a network component. The work examines the sources and ways of forming indexes, the

purpose of indexes, as well as the objects of network analysis. It was determined that the objects of analysis are network components, end equipment, web resources, and the state of their protection. The state of protection is determined by secondary characteristics based on traffic analysis or external vulnerability scanning network analysis objects. The NMI model is proposed, which considers network traffic analysis data, vulnerability scan results, and threat intelligence data. Calculation data of the NMI for critical information infrastructure objects are in progress.

In chapter ***Tensor Methods in Cyber Security*** by **I. Grygoryeva, L. Yona and A. Mazur**, the authors highlight that information technology development and intensive use of the Internet have revealed problems related to information security. The issues of protecting information transmitted through communication channels and requiring long-term storage become relevant; the need for authentication procedures for users and messages; improving system performance and reliability. Various tasks of modern information security are solved with the help of cryptographic protocols. Various sections of higher mathematics are successfully used in information protection tasks. In this article to increase the effectiveness of information protection means, it is proposed to use such a mathematical apparatus as tensor analysis. The possibility of using tensor methods in solving various problems of cryptographic protection of information is shown. As a result of tensor analysis operations, this article shows the possibility of encrypting messages and decrypting cryptograms. The possibility of using tensor analysis in the construction of hash functions is shown additionally. In order to increase the effectiveness of means of protecting confidential information, it is proposed to encrypt messages using tensor analysis operations. At the same time, there is an increase in the speed of the process of ensuring the protection of confidential information in the implementation of document flow.

Part III Geoinformation Systems and Remote Sensing of the Earth.

In chapter ***Cloud platforms and technologies for big satellite data processing*** by **N. Kussul, A. Shelestov, B. Yailymov**, the authors address the problem of processing large volumes of satellite data and compare different cloud platforms for potential solutions. Existing cloud platforms like Google Earth Engine, Amazon Web Services (AWS), and CREODIAS have been used to tackle this challenge. However, this study proposes an optimal pipeline for satellite data processing, taking into account the advantages and limitations of each platform. The specific focus is on solving machine learning problems using satellite data. In the experiment conducted, the effectiveness of each cloud platform was analyzed. It was found that cloud platforms offer benefits such as flexibility, access to computing resources, and parallel processing architectures, leading to increased productivity and cost reduction. CREODIAS, in particular, stands out due to its specialization in satellite data and easy access to various data types, along with tools for data searching and visualization. The experiment demonstrated that tasks, from data loading to classification, were executed fastest on CREODIAS resources. However, AWS performed data classification faster. The availability of its own internal data bucket was a significant advantage of CREODIAS, especially when considering ARD data. These findings contribute to the advancement of AI methodologies and have practical implications for solving satellite monitoring applications.

This chapter ***Current Advances on Cloud-Based Distributed Computing for Forest Monitoring in Ukraine*** by **A. Shelestov, Y. Salii, N. Hordiiko, H. Yailymova** addresses the crucial task of forest monitoring for environmental protection. They highlight the challenge of handling big data and the need for powerful computing resources, which are not always readily available. To overcome these obstacles, the authors explore cloud solutions like CREODIAS and Google Earth Engine, which offer instant access to satellite data and efficient processing of geospatial information. The study focuses on analyzing Sentinel-2 satellite spectral channels to differentiate between diseased and healthy forests using the Bhattacharya distance. The informative nature of applying the normalized difference vegetation index (NDVI) over time is also examined, confirming that changes in the forest lead to a decrease in average NDVI value and an increase in standard deviation. To address the big data issue, the authors propose the structure of a pilot information system as a foundation for a cloud-based solution. The system involves the development of a machine or deep learning model for forest monitoring, applicable to any territory, including Ukraine. By implementing this system, it becomes possible to monitor forest dynamics based on time series of satellite data at a national and global level. This advancement is particularly significant for Ukraine, as it positions itself as a potential EU member in providing information services and monitoring vital natural resources, contributing to environmental preservation and sustainable management.

This chapter ***Cloud-based Technologies Google Earth Engine for monitoring surface deformation of the Solotvyno agglomeration*** **by O. Hordiienko, Y. Anpilova, Y. Yakovliev and O. Rogozhin** utilizes the Google Earth Engine (GEE) service to analyze satellite images, aiming to determine human-induced spatial and temporal changes in the man-made water surface and identify anthropogenic alterations in the Solotvyno salt mine agglomeration. GEE enabled efficient processing of large geospatial datasets in the cloud, employing masks and machine learning for a wide range of computational operations. The masking method, using threshold values and image preprocessing, offered a simpler approach to track vertical relief displacements. Additionally, it provided accurate and prompt research results. By employing water surface masks and analyzing Sentinel-1 and Sentinel-2 satellite images, it was observed that the area of land subsidence and water presence above flooded mining areas increased from 2015 to 2023, displaying a tendency for further expansion. These findings can be utilized to identify risk areas, inform decisions regarding ecosystem preservation and sustainable territorial development, and predict potential damage to critical infrastructure. The primary focus is on using threshold masks for active satellite data to detect inundation zones where vertical relief displacements occur, enabling the calculation of their areas and sizes. This approach was compared to passive data, which exhibited a similar trend over the entire time frame. The method offers a quicker and more accessible means of detecting vertical relief displacements compared to methods such as classification and interferometry.

This chapter ***Multicriteria optimization method for monitoring the water quality urbanized lakes of the Opechen system of Kyiv based on remote sensing information*** **by S. Zahorodnia, I. Radchuk, N. Sheviakina, O. Tomchenko and A. Khyzhniak** considers the possibility of using the multi-criteria optimization method, which allows for a holistic evaluation of various environmental criteria. The main goal is the development and implementation of a multi-criteria optimization method for monitoring the

quality of water bodies using information from remote sensing of the Earth and information from field studies. Compared to conventional monitoring approaches, this method demonstrates the advantage of providing a more accurate and informative assessment of water quality criteria. The proposed method uses a weighted linear combination approach of water quality criteria based on stakeholder preferences and expert knowledge. By as-signing appropriate weights to each criterion, the method effectively prioritizes and aggregates various water quality indicators. An approach is evaluated an example the limnological system of Lake Verbne (Kyiv), the relationship between all the obtained characteristics of the lake was analyzed using the methods of system analysis, and an assessment was made by combining heterogeneous data characterizing the ecological state. The result of the proposed assessment is a set of heterogeneous data characterizing the ecological state of the water body by the method of multi-criteria optimization. The optimization process facilitates the identification of areas that require immediate attention and targeted efforts to conserve and define the dynamics of urbanized water bodies.

Part IV Mathematical Modeling in Applied Problems.

In chapter ***Selecting a Polynomial for Estimating the Motion Parameters of a Permanently Maneuvering Group of Unmanned Aerial Vehicles*** by **O. Tsukanov and Y. Yakornov**, the authors presented the choice of polynomial for estimation of motion parameters of unmanned aerial vehicles, which are in a constellation and perform abrupt maneuvering or permanently maneuvering; the efficiency of this approach estimation is carried out by methods of mathematical modeling. This choice is based on the Kalman–Bucy filter which allows us to obtain both stable state vector estimates and high accuracy for the majority of motion variants, except for the case of permanently maneuvering object. Therefore, for the latter case, the possibility of increasing the accuracy of the estimation of motion parameters with the help of Chebyshev polynomials, polynomials based on the Taylor series or algebraic and polynomials, also based on the Puise series or fractional polynomials by the least-squares method in a sliding window, which can be set as a time interval or number of measurements and on which further the approximation coefficients of the polynomial and the estimate of the required parameter are determined. The main attention was paid to studying the possibilities of fractional polynomials based on the Taylor series, rarely used in technical applications. A comparative evaluation of these methods was carried out and the optimal fractional polynomial degree and sliding window width according to the criterion of minimizing the square of the estimation errors was found by simulation. In particular, it is received that the best method in accuracy is the method of least squares in "sliding window" with fractional powers of 1/2 through 1 at the maximum length of a window, and at the minimum length—Chebyshev polynomials of 2, 3 orders.

I. Melnyk, S. Tuhai, M. Skrypka, T. Khyzhniak, A. Pochynok (*A New Approach to Interpolation and Approximation of Boundary Trajectories of Electron Beams for Realizing Cloud*) present a new method for interpolation and approximation of the boundary trajectory of a short-focus electron beam propagated in ionized gas. The approach involves compensating the space charge of electrons by the ions of residual gas using root-polynomial functions of different orders. The authors demonstrate that root-polynomial functions always satisfy the second-order differential equation, which

accurately describes the boundary trajectory of an electron beam in physical conditions typically associated with short-focus beams generated by high-voltage glow discharge electron guns. The interpolation results are validated against numerical solutions of the differential equation, showing an interpolation error of less than a few percent. For experimental data obtained from industrial high-voltage glow discharge electron guns operating under realized technological conditions, the approximation problem is successfully solved using the least-squares method, with approximation errors also in the range of a few percent. The proposed approach has practical applications, allowing for an estimation of the technological possibilities of forming an electron beam with required parameters in cloud computing. Engineers can use this approach to obtain relevant results in the polynomial coefficients during the initial design stages of industrial electron beam equipment. The theoretical results presented in the paper are of significant interest and importance for experts in computer science and network technologies. For instance, the root-polynomial functions introduced can be considered as membership functions in fuzzy logic tasks, further simplifying complex numerical simulations in cloud networks.

In chapter ***Genomic Data Machined: The Random Forest Algorithm for discovering breast cancer biomarkers*** by **N. Kasianchuk, D. Tsvyk, E. Siemens, V. Ostash, and H. Falfushynska**, the authors propose a modern approach to supporting analysis in healthcare systems. Advanced data analysis tools and bioinformatics are essential for uncovering the nature of breast cancer, which is the leading cause of cancer death among women. The goal of this study is to identify potential genomic biomarkers that have a significant impact on four prognostic factors, including tumor size, lymph node involvement, metastasis, and overall survival status. The random forest algorithm has been trained on data from The Cancer Genome Atlas Breast Cancer, which contains the expression values of 19,737 genes. In order to obtain the optimal learning model, the process has been repeated 20 times for each indicator, and only the genes with a p-value <0.05 were taken into further consideration. Several performance metrics (e.g., F1 score) were calculated to check the algorithm's reliability. As a result, 97 and 7 genes were included in the extended and final databases, respectively. The chosen genes have been proven to play a critical role in cancer-related pathways, such as Toll-like receptor and NF-κB, and have effects on cell proliferation, tumor formation, and angiogenesis. Thus, this study demonstrates the potential of machine learning analyses for biomedical purposes and provides machine-generated insights into breast cancer development, setting the groundwork for further in vitro examinations to validate the prognostic potential of these biomarkers.

The Chézy roughness coefficient is discussed by the **Y. Khodnevych, D. Stefanyshyn and V. Korbutiak** in the chapter ***The Chézy roughness coefficient computing using an artificial neural network to support the mathematical modeling of river flows***. Chézy's coefficient enables to control of a majority of factors and parameters determining the hydraulic resistance to open flows in river channels. A challenge is that the Chézy coefficient may not be determined directly using field measurements or experimentally. To compute the Chézy roughness coefficient, a large number of empirical and semiempirical formulas have been developed by various authors. However, as practice shows, there is no ideal way or method to determine the Chézy roughness coefficient. Often, the appropriate formula choosing can become a challenge for researchers.

Supporting the comprehensive and holistic approach to hydraulic resistance research, this article presents preliminary results of solving the problem using an artificial neural network. The problem is solved with the example of a neural network of direct propagation with one hidden layer and a sigmoid logistic activation function. The Python object-oriented programming environment was applied to build and train the neural network. The neural network training was carried out according to the actual data of hydro-morphological observations in rivers. The network testing was performed with a comparison of the observed (gauged) and computed (predicted) water discharges. The Nash–Sutcliffe model efficiency coefficient was used to assess the predictive skill of the network.

We would like to sincerely thank the authors of this collection, because without their hard work of preparing good chapters this volume would not have been successfully prepared.

First and foremost, we extend our sincere thanks to Prof. Janusz Kacprzyk, the Series Editor from the Polish Academy of Sciences, for his valuable guidance and support throughout the entire process.

We are immensely grateful to Dr. Thomas Ditzinger, Executive Editor of Interdisciplinary and Applied Sciences & Engineering, for his insightful inputs and continuous encouragement that significantly enriched the quality of this work.

Our special appreciation goes to Mr. Nareshkumar Mani, the Project Coordinator—Total Service Books Production, for his unwavering dedication and meticulous coordination, ensuring the smooth execution of the project.

And last but not least, we extend our heartfelt thanks to all our colleagues at Springer Nature for their relentless commitment to maintaining the highest publication standards and their invaluable assistance in bringing this project to fruition. Without the collective efforts and support of these esteemed individuals and the entire team, this publication would not have been possible. Their contribution has been instrumental in meeting our deadlines and achieving excellence.

Once again, thank you all for your invaluable contributions and dedication to the implementation and timely completion of this large publication project maintaining the highest publication standards.

July 2023

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About This Book

This book gathers selected papers of the most important research results in the fields of information and communication technologies, geoinformation systems, and mathematical modeling, prepared by various groups of researchers from Ukraine in cooperation with scientists from different countries. The authors of the chapters' collection present in-depth and extended results of research in their scientific fields.

The book covers state-of-the-art research insights on modern society and environment sustainable development based on the conception of global information space, development of next-generation mobile communication systems, software-defined networks, trends in ICT technologies and systems such as automated special purpose systems, the IoT systems practical implementation, the basics of analytical activities, ontological modeling, energy-efficient workload processing technologies in the data center, and the new multidimensional cryptosystems implementation; the modern study of geoinformation systems and remote sensing of the earth; research in fields of mathematical modeling in applied problems deals with optimization of the group of unmanned aerial vehicles movement, the study of new approach for cloud computing, and examples of using artificial neural networks.

Keywords

- Society and environment sustainable development
- Geoinformation systems and remote sensing of the earth
- Software-defined networks
- Internet of Things
- Next-generation mobile communication systems
- Energy-efficient workload processing
- Security and multidimensional cryptosystems
- Artificial neural networks

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