Lecture Notes on Data Engineering and Communications Technologies

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The aim of the book series is to present cutting edge engineering approaches to data technologies and communications. It will publish latest advances on the engineering task of building and deploying distributed, scalable and reliable data infrastructures and communication systems.

The series will have a prominent applied focus on data technologies and communications with aim to promote the bridging from fundamental research on data science and networking to data engineering and communications that lead to industry products, business knowledge and standardisation.

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Andriy Semenov · Iryna Yepifanova ·
Jana Kajanová
Editors

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Editors
Andriy Semenov
Faculty of Information Electronic Systems
Vinnytsia National Technical University
Vinnytsia, Ukraine

Iryna Yepifanova
Faculty of Management and Information Security
Vinnytsia National Technical University
Vinnytsia, Ukraine

Jana Kajanová
Department of Economics and Finance
Faculty of Management
Comenius University Bratislava
Bratislava, Slovakia

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Preface

Ukraine is a country in extreme economic and social conditions. An in-depth analysis of economic, social, demographic, and other processes will be interesting for a large number of countries throughout the world. It may reveal the limits of stability of the economy and society and the system of risks that survive in such conditions. Innovative processes, the creation and dissolution of enterprises with various forms of ownership, and mass internal and external migration are all phenomena that may enrich world science. The wide use of information technologies allows for the creation of various databases and the formation of a powerful analytical apparatus. In this book, an in-depth study of a large number of economic and social processes is carried out, which allows for a deep understanding of the phenomena that accompany the high risks of their operation. Here, in the conditions of formation of new approaches to the analysis of various social and economic object functioning in high-risk conditions, new approaches to analysis and forecasting are summarized. These approaches can seriously affect the development of communication technologies for the subjects of economy and society, forming new directions of information technologies development.

In the preface, we provide brief overviews of each study included in the volume. The first chapter, titled "Evaluation of the Level of Efficiency of Time Management at the Enterprise Using the Theory of Fuzzy Sets," uses the theory of fuzzy sets to analyze the efficiency of time management. The authors consider three types of time management: individual, corporate, and professional. They developed an algorithm to calculate the level of time management efficiency in the enterprise using linguistic variables, membership functions and fuzzy rules for the transition from fuzzy values of quantities to specific parameters. The authors' approach enables the creation of a predictive model of the state of time management at the enterprise. The results obtained with this approach can be used to develop measures to improve the time management system at the enterprise, taking into account the achievement of its strategic goals.

The next chapter, "Financial Security Management of Enterprises in Conditions of Uncertainty," describes the option of managing the financial security of an economic entity using systemic, process, mechanistic, and strategic analyses. System analysis

is used to manage the financial security of the enterprise as a whole set of elements in a complex of connections between them. Process analysis includes the entire set of operations that are performed on input flows (process inputs) and lead to obtaining an additional result (process outputs). Mechanistic analysis uses the main elements of management (methods, technologies, tools, etc.) in the process of developing and implementing the protection of the company's financial interests. Strategic analysis substantiates the formation and implementation of appropriate strategies to achieve the required level of enterprise security management. Using the results of the analysis, the authors developed an information model for enterprise security management. This model allows for algorithmization and can be used for a wide range of tasks of sustainable enterprise management in turbulent environments for many countries of the world.

In the chapter "Integration of Operational and Economic Security of the Enterprise: Reorganization, Technologies, Risks and Outsourcing," the authors discuss the importance of operational and economic security for the stability and success of companies. In the context of IT outsourcing, operational security refers to data access control, while economic security involves cost transparency, financial management, and contractual terms. The authors analyzed and evaluated fifty threats and developed an algorithm to determine the feasibility of outsourcing functions and the integration steps for reorganizing operational and economic security in an industrial company. They demonstrated that ensuring operational and economic security requires an integrated approach, including strategy development, security implementation, continuous policy and procedure updates to minimize risks and ensure operational success. These findings can encourage similar studies to consider the specific characteristics of individual countries in the outsourcing development process.

In the next study titled "Financial Assurance for Tourism Development and Its Impact on the Economy of European Countries," various economic indicators of the tourism sector in European countries were analyzed using data from organizations such as UNWTO, the European Commission, European Statistics, European Parliament, and the European Court of Auditors. The study found that the tourism sector in European countries is growing and is resilient to global economic challenges. The authors have developed a model for creating and implementing a financial mechanism that can support the development of tourism in European countries by distributing investment resources. This model considers the unique characteristics of the European tourism market and balances the interests of key stakeholders in the tourism industry, including tourists, tourism businesses, and government policies. The practical application of these findings can help optimize the strategy for tourism development as part of the sustainable development of the European Union as a whole.

In the subsequent chapter, "Innovative Mechanisms for Regulating the Social Welfare of Refugees: Demographic Collapse or Sustainable Development," the authors argue that for Ukraine today, the social welfare of refugees is one of the critical directions for the formation of sustainable development. Existing databases with a large number of demographic indicators were analyzed. The authors concluded

that the potential for demographic growth has already been exhausted in Ukraine. The reasons for this are a low share of the population of working age, high mortality of the adult population, significant migration flows, uneven distribution of the population across the country, and deterioration of the ecological situation. It was found that a promising tool for achieving sustainable development is the use of innovative mechanisms for regulating the level of social security of refugees. For this, the authors have developed a set of mechanisms for the regulation of the social welfare of refugees on an innovative basis, which are based on innovations in business and regulatory, administrative, social, and information technologies to optimize the regulation of public welfare. The developed mechanisms allow the use of quantitative characteristics on the basis of which appropriate databases can be formed. This can be used to automate their analysis and information-technological support for the formation of a sustainable development regime in Ukraine.

The study "Innovative Management of Regional Business: Financial Technologies and IT Tools," presents an analysis of existing innovative business management tools based on financial technologies and IT solutions. The authors conducted a SWOT analysis for the development of financial technologies in the regions using IT tools. It was found that among the main FinTech solutions there are the recognition of digital currencies by central banks, decentralization and regionalization of financial platforms, as well as the spread of personalized financial services based on artificial intelligence. All these tools can have an effective impact on the innovative management of regional business. The authors suggest the following potential opportunities for the spread of the digital financial services market, in particular: retail trade, e-commerce, real estate market, travel, media, entertainment, energy supply, etc. It has been proven that the joint efforts of FinTech companies and traditional banks create positive synergy. As a result, it may change the future of financial services, offering an improved customer experience, simplifying processes, and innovating products not only at the national but also at the regional and local levels.

In the next study, titled "Using Machine Learning Algorithms to Analyze Energy Consumption Data and Optimize Management Processes at Smart Enterprises," attention is drawn to the application of ML in various sectors, including manufacturing, retail, and data centers, and to forecasting and optimizing consumption energy. The paper analyzes the experience of leading corporations such as Toyota, Walmart, Google, and Siemens in using ML to promote corporate sustainable development goals. The authors developed an algorithm for the application of machine learning in energy management. It covers all stages of the business process, from data collection to application for operational improvements and sustainability, and allows not only to optimize energy consumption but also to increase the overall efficiency and stability of production activities. The authors point to the following prospects for the implementation of ML, which may also be useful for EU countries: integration with IoT to improve real-time data collection and analysis, advanced predictive analytics, creation of fully autonomous systems, and increased management stability.

The subsequent chapter, "Methodological and Legislative Tools for Management of Assimilation of Labor Migrants," explores directions for the main trends in the functioning of labor migration, which include taking into account the demographics

of the country and the subsequent lack of labor on the market, unemployment and crises in the least developed countries, etc. The authors analyze the following main groups of tools for the assimilation of labor migrants: economic, political, social and cultural processes. A number of normative legal acts proposed by the international community, as well as conventions and legislative initiatives regarding the regulation and protection of the rights of labor migrants, which will especially stimulate the process of their assimilation, have been analyzed. The authors emphasize that the rapid pace of digitization and technological changes create new opportunities and challenges for labor migration. Future strategies should consider the implications of digital work platforms, remote work, and the digital skills gap for migrant workers. This direction of information technology development can also be important for developed countries with a high level of migration.

Further, the chapter "Education as a Driver of Innovative Recovery and Economic Development of Ukraine," draws attention to the analysis of problems that took place in the education system of Ukraine and catastrophically worsened as a result of the full-scale war in the country. The authors' goal is to develop methods of using information technologies and digitization for the development of the education system at a new technological level for the preservation and development of the country's human capital. The work analyzes the database of statistical data on the influence of martial law on demographic trends, migration of the working population, etc. The authors propose to use modern information technologies for distance, stimulation, and motivation of educational and scientific activities of young people, development of individual perception, and creative thinking of high school students and university students. It is also proposed that these technologies be used to train young people in the professions that will be needed in Ukraine during the post-war economic reconstruction stage. Attention is drawn to the prospect of involving manufacturing companies to participate in the educational process. Countries with a high level of migration also face similar problems, and therefore, the experience of Ukraine can be useful for them.

In the next study, titled "Increasing the Coverage of Social Protection in Case of Unemployment Through Employment Formalization," the authors analyzed the system of results regarding the level of unemployment in the period before the military attack on the territory of Ukraine. The experience of the countries of the world in the direction of the development of the system of social protection of the unemployed was analyzed. It is shown that social protection systems are based on state mechanisms of official registration of employment and take into account the specific features of the labor market of the respective countries. The authors have developed directions for the formation of methods and procedures for formalizing the coverage of the unemployed with social protection in Ukraine in order to increase the level of inclusive development of society, the economy, and the state. The obtained results can be used to form appropriate databases and create analytical material that can be used by the state to reduce the level of informal employment in Ukraine during the post-war reconstruction period. Methods and approaches to the formation of information technologies can also be useful for developed countries in conditions of recession and high levels of migration.

In the next chapter, titled "Modern Information and Analytical Support and Its Impact on International Competitiveness," the author examines existing databases on the development of information and analytical support for conducting business in developed countries and its impact on their competitiveness in the world market. The analysis results were applied to identify promising directions for the development of information technologies in Ukraine, which can enhance the economy's efficiency and its integration into the global economy. The crucial role of the state and regional authorities in Ukraine in effectively managing the development of information technologies to achieve a high level of competitiveness in the modern world is being emphasized.

Developing sustainable technologies for converting biomass into value-added chemicals is a crucial component of the green transition in various industries, particularly the pharmaceutical sector. The chapter "Simulation of Biomass Processing into Furfural Using ChemCad," explores the simulation of biomass processing into furfural using the ChemCad software, a versatile tool for designing and optimizing chemical processes. Furfural, a key platform chemical derived from lignocellulosic biomass, serves as a precursor to a range of industrially significant compounds. Given its importance, optimizing the production process for furfural can significantly enhance its economic viability and environmental sustainability. This study utilizes ChemCad to model the conversion of various biomasses, such as birch wood and olive tree residues, into furfural. The simulation incorporates multiple ChemCad modules, including equilibrium reactors, filters, and liquid-liquid extractors, and addresses the challenges of integrating biomass-specific components into the database. The thermodynamic model UNIFAC LLE plays a central role in accurately simulating the behavior of ternary systems involved in the process. This work not only demonstrates the feasibility of using ChemCad for such complex simulations but also provides valuable insights into the selection of raw materials and processing methods, thereby contributing to the broader goals of sustainable chemical production.

In the chapter titled "Digital Transformation to the Efficiency and Sustainability of Cities," the authors proposed to consider the potential of digital transformation and the influence of institutional effects on the efficiency of the development of modern cities and the concept of sustainability of smart cities. The advantages of using information and communication technologies on the way, from implementing the concept of a smart city to developing a democratic state, are described. It was revealed that the causes of challenges on the path of digital transformation are the insufficient level of development: a unified approach at the state and local levels, digital infrastructure, automation and digitization of public services, digital literacy of the population, and the presence of digital "inequality" at the level of communication between the population and local self-government. The cities of many world countries also face similar problems, and the digitalization experience in Ukraine can be useful for them.

In the forthcoming chapter, "Risk Management Strategies of Generation Z Consumers in Online Shopping," the authors explore online shopping for clothes and shoes by Generation Z in Ukraine during the COVID-19 pandemic and the war. A structured survey was conducted to collect data from 634 online shoppers,

and SPSS tools were used to conduct a comprehensive data analysis. The influence of such factors as gender, academic performance, and level of social activity was analyzed. Significant differences in risk management strategies depending on these factors were revealed. They affect, in particular, (1) relation to the possibility of product testing, (2) availability of guarantees and indemnities, (3) effective communication to mitigate product quality risks, (4) financial losses, and (5) inadequate warranty services. Gender differences were also revealed: women rate the methods of managing the first three risks higher than men. The study results can be used for a comparative analysis of the characteristics of online shopping by Generation Z of clothes and shoes in different countries and under different conditions in society. These results can also be included in online shopping risk management databases in many countries worldwide, improving the effectiveness of applied forecasting.

Advancements in optical metrology and image processing have increasingly relied on expert systems to ensure the accuracy and quality of measurements in complex diffraction scenarios. The chapter "Expert System to the Image Quality Assessment in Diffraction Problem with Linearly Polarized Beam," presents an expert system specifically designed for assessing image quality in diffraction problems involving linearly polarized beams. The system integrates a combination of statistical analysis, empirical methods, and Bayesian inference to create a robust knowledge base that guides the evaluation process. The approach involves both quantitative metrics, such as signal-to-noise ratio, contrast ratio, and structural similarity index, as well as expert evaluations that consider the influence of topological objects like optical vortices on image quality. By focusing on these core aspects, the system provides a comprehensive framework for determining the validity and reliability of optical images, especially those generated in experiments with phase converters like the double phase ramp. The significance of this work lies in its potential to improve the precision of measurements in optical fields and to broaden the applicability of expert systems in various diffraction-related challenges. Future enhancements involve integrating machine learning for improved object recognition and expanding the system's capability to address a wider array of optical problems.

In the chapter "Features of Digitalization of the Process of Submitting Applications for Grant Programs at the University Level Using Information Technologies," the authors performed a comparative analysis of submitting an application for a state grant at the university level in the world and in Ukraine. The purpose of the work is that the full digitalization of the process of submitting applications for grant funding will allow us to optimize this process, using information technologies in the form of a developed specific information resource at the university level. The authors analyzed the possible system of possible conflicts of interest between the scientist who submits the application and the university, the manufacturer (which implements the result), the society, and the government. The developed information technology promotes creating a number of important conditions for increasing the efficiency of scientific activity in Ukraine. The use of the developed information resource allows to optimize the process of applying for a grant, recording all the stages of the first stage of the application, which is carried out within the framework of a university or scientific institution. It also allows to completely avoid all

the above-mentioned problems related to copyright and the right to real property. The authors developed proposals for changing the existing Order of the Ministry of Education and Science of Ukraine. The results of this chapter may be of interest to a wide range of researchers who are engaged in optimizing the grant system in both developed and developing countries.

In the study titled "Methodology for Assessing the State of Business Processes in Terms of Their Impact on the Economic Security of the Enterprise," the authors use an expert assessment of business processes and an analysis of the structural graph built for them. The following seven business processes were used: (1) product research and development; (2) material and technical support; (3) related to production; (4) logistics; (5) marketing support; (6) financial support of activities; (7) quality management. Thirty-four experts were involved in quantifying the impact weight of each business process. For optimization, a mathematical model was proposed for quantitative calculation of the actual level of influence of each individual business process on the economic security of the enterprise. The authors gave an example of the application of the developed apparatus for assessing the state of economic security for a specific enterprise in Ukraine. The use of this methodology will allow for forecasting the level of economic security of Ukrainian enterprises both during martial law and at the stage of post-war reconstruction. This can be important for the formation of relevant databases, which can be used to optimize international investments in Ukraine's economy.

In the next study, "Entrepreneurship as a Factor in Strengthening the Competitiveness of the Regional Economy: Information and Analytical Assessment of Problems and Development Prospects," the authors propose the results of the analysis of problems and prospects for the development of small and medium-sized enterprises (SMEs) on the example of Vinnytsia and Khmelnytskyi regions of Ukraine with the involvement of various groups of interested parties. Both official statistical and informational materials and primary information from its own sociological research ("field" research) and focus groups were used. The authors studied the following population groups: residents of the community who are consumers of services and products of SMEs, local and relocated from the zone of hostilities of SMEs, as well as local self-government bodies, whose powers include supporting and promoting the development of SMEs. The obtained results can be used for the formation of databases and testing of the analytical tool at the stage of optimizing the functioning of the regional economies of Ukraine both during martial law and during the recovery period of Ukraine. This may optimize the direction of foreign financial aid at the stage of reconstruction.

Integrating Internet of Things (IoT) technology in dairy farming represents a significant advancement in automating and optimizing production processes, particularly for farms utilizing tethered cow systems. The chapter "Information System Based on the Internet of Things Technology for the Dairy Farms with Tethered Cows" presents an innovative information system designed specifically for such dairy farms, offering remote and continuous monitoring of various technological parameters related to cow's milk production. The system is built to detect and analyze critical events, monitor compliance with operational protocols, and manage milk

accounting, thereby enhancing both productivity and quality control. Key components of this system include electronic milk dispensers, vacuum pump control units, and washing machine control units, all connected via an interface unit with data stored and synchronized across multiple devices using a Raspberry Pi 4. The system enables farm operators to access real-time data and historical records from any location, improving decision-making and ensuring regulatory adherence. By addressing the specific needs of dairy farms with tethered cows, this information system not only boosts efficiency but also contributes to the broader movement toward smart agriculture, where IoT technology plays a central role in transforming traditional farming practices.

In an era where road safety and efficient traffic management are paramount, developing precise and cost-effective vehicle speed detection systems has become increasingly important. The next chapter, "Computer System for Vehicle Speed Determination," introduces a computer system designed to determine vehicle speed using a Raspberry Pi 4 single-board computer, the Raspberry Pi camera module, and the OpenCV image recognition library. The system is distinguished by its ability to detect and measure the speed of vehicles within a predefined rectangular zone, minimizing the influence of extraneous objects in the camera's field of view. By employing advanced image processing techniques such as Gaussian blurring and Otsu's binarization, the system accurately tracks the movement of vehicles and calculates their speed. This prototype is particularly effective for vehicles traveling at speeds up to 60 km/h, offering a practical solution for a range of applications, from traffic monitoring to automated enforcement. Future enhancements, including the capability to detect vehicles in low visibility conditions by recognizing headlights, are proposed to improve the system's functionality and adaptability further.

Optimizing energy consumption while maintaining production efficiency has become a critical challenge for enterprises in the context of rising energy costs and frequent supply interruptions. The chapter titled "Mathematical Model of Intellectual Decision-Making Support for the Selection of the Enterprise's Optimal Production Plan Under Conditions of Energy Restrictions" presents a mathematical model designed to support intelligent decision-making for selecting an optimal production plan under energy constraints. The model leverages the capabilities of a two-layer perceptron neural network to forecast an enterprise's energy consumption based on various input factors, including production volume, external temperature, and the availability of alternative energy sources. By approximating the nonlinear relationships between these variables, the model enables enterprises to determine the most energy-efficient production plan while adhering to energy restrictions, such as limited power supply or the need to switch to backup energy sources. The model's robustness is demonstrated through simulations that account for varying external temperatures and production conditions, ensuring that enterprises can maintain operations without exceeding their energy limits. This innovative approach offers a valuable tool for enterprises seeking to balance production needs with energy efficiency, thereby enhancing their competitiveness and sustainability in a resource-constrained environment.

The shift towards sustainable consumption practices has become an essential area of focus for marketers, governments, and educational bodies alike. As the principles of the circular economy gain prominence, it is increasingly important to understand how children, a key demographic in consumption and family decision-making, perceive and engage with these principles. The chapter "Harvesting Hope Through the Circularity Promotion in Children's Food Marketing" delves into the intersection of children's food consumption habits, marketing strategies, and circular economy values. Based on a comprehensive survey conducted with Ukrainian youth aged 6–16, the study explores the varying levels of awareness, engagement, and practical application of circular economy concepts among children. By categorizing respondents into three distinct groups—enthusiastic followers, cautious considerers, and unengaged conservators—the research offers insights into how children can become agents of change within their households and communities. The analysis reveals both promising engagement levels and significant gaps in knowledge, highlighting the critical need for educational initiatives and sustainable marketing strategies that resonate with young consumers. The chapter further emphasizes the role of families, educators, and policymakers in fostering a circular mindset that can reduce waste and promote a more sustainable future for food marketing.

In today's dynamic and rapidly evolving economy, businesses continuously seek innovative methods to enhance employee engagement, motivation, and productivity. One such approach that has gained traction is gamification, integrating game mechanics into non-game contexts to inspire desired behaviors. The next chapter, titled "Gamification: A New Approach to Motivating Employees and Its Implications in the Modern Economy," explores the rise of gamification as a transformative tool in workplace environments. Organizations have redefined performance management by incorporating elements such as points, badges, and leaderboards, driving employees toward higher efficiency and innovation. Gamification aligns intrinsic and extrinsic motivations, fostering a competitive yet collaborative atmosphere where employees can track their progress and feel rewarded for their achievements. This shift is not merely cosmetic; it reflects a broader cultural change, where technology and human-centric design converge to reshape traditional business models. However, as with any innovation, the successful implementation of gamification depends on careful design and execution, and this chapter delves into both its potential and limitations in achieving sustainable organizational success in the modern economy.

As the world embraces digital transformation, big data, artificial intelligence, and analytics are reshaping human resources management. The final chapter, "Data Analysis in Human Resources Management: A Systematic Review Research of E-Society," examines how these technologies are being integrated into human resources processes and the challenges they bring. Human resources have traditionally relied on personal judgment and qualitative assessments; however, the advent of data-driven tools promises more objective, efficient, and predictive decision-making in recruitment, employee performance evaluation, and talent management. This systematic review consolidates existing research on the digitalization of human resources, focusing on the application of data science while also discussing concerns such as data privacy, ethics, and the psychological impacts of artificial intelligence

on employees. Although human resources digitalization is still in its nascent stage, its potential for transforming organizational practices is vast. The chapter underscores the importance of equipping human resources professionals with the necessary skills to navigate this technological shift while also addressing the need for ethical frameworks to guide the responsible use of employee data in this new era.

Vinnytsia, Ukraine
Andriy Semenov
semenov.a.o@vntu.edu.ua

Vinnytsia, Ukraine
Iryna Yepifanova
yepifanova@vntu.edu.ua

Bratislava, Slovakia
Jana Kajanová
jana.kajanova@fm.uniba.sk

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