electronics

MDPI

Editorial

Advanced Technologies and Applications in Computer Science and Engineering

Ognyan Nakov [1], Milena Lazarova [1] and Nikolay Hinov [2,*]

[1] Department of Computer Systems, Faculty of Computer Systems and Technologies, Technical University of Sofia, 1000 Sofia, Bulgaria; nakov@tu-sofia.bg (O.N.); milaz@tu-sofia.bg (M.L.)
[2] Department of Power Electronics, Faculty of Electronic Engineering and Technologies, Technical University of Sofia, 1000 Sofia, Bulgaria
* Correspondence: hinov@tu-sofia.bg

Abstract: This editorial article introduces the Special Issue entitled "Advanced Technologies and Applications in Computer Science and Engineering", which highlights a diverse range of contemporary research and technological advancements in these fields. The issue features selected contributions that explore cutting-edge innovations, including artificial intelligence, machine learning, quantum computing, the Internet of Things, and big data analytics, emphasizing their transformative impact on industry, science, and society. The articles address both theoretical advancements and practical applications, showcasing novel approaches to solving complex computational and engineering problems. Special attention is given to the challenges associated with the integration and implementation of these emerging technologies, including scalability, security, and ethical considerations. The selected studies present innovative solutions in key areas such as robotics, network security, cloud computing, and data-driven decision-making, contributing to the development of efficient, intelligent, and sustainable technological solutions. By bringing together a multidisciplinary perspective, this Special Issue aims to foster collaboration among researchers, engineers, and industry professionals, ultimately advancing the frontiers of computer science and engineering.

Keywords: artificial intelligence; big data; quantum computing; Industry 4.0; Internet of Things; machine learning; robotics; network security; technological innovation; societal transformation

Received: 8 February 2025
Revised: 12 February 2025
Accepted: 13 February 2025
Published: 14 February 2025

Citation: Nakov, O.; Lazarova, M.; Hinov, N. Advanced Technologies and Applications in Computer Science and Engineering. *Electronics* **2025**, *14*, 753. https://doi.org/10.3390/electronics14040753

1. Introduction

In today's rapidly evolving world of technology, computer science and engineering are playing a key role in transforming industries and society as a whole. From artificial intelligence and machine learning to the Internet of Things and quantum computing, new technologies are offering innovative solutions to complex problems, improving efficiency and productivity. These developments are not only leading to significant progress in traditional engineering fields, but are also creating new applications that are rethinking the way we interact with the digital world.

In the field of artificial intelligence and machine learning, significant progress has been made in AI theory and practice. Developments in neural networks and machine learning algorithms have improved the capabilities of AI systems in recognizing patterns, decision-making, and learning from data without explicit programming [1]. Deep learning has revolutionized fields such as image recognition, natural language processing, and

autonomous driving by enabling machines to process and understand vast amounts of data with a level of accuracy that often surpasses human capabilities [2].

Quantum computing has seen the design of new algorithms that exploit quantum mechanical properties to perform computations more efficiently than their classical counterparts, potentially solving problems previously considered intractable [3,4]. Innovations in quantum communications promise ultra-secure data transmission channels due to the principles of quantum mechanics, which could revolutionize data security [4,5].

The Internet of Things (IoT) has benefitted from innovations in frameworks that support more efficient data collection, processing, and transmission. These enhancements enable smarter cities and industries through improved resource management and service delivery [6]. Advances in IoT security ensure better protection against hacking and data breaches, addressing the growing need to safeguard expanding IoT ecosystems [7].

Big data and analytics have experienced significant growth, with the emergence of tools and technologies that facilitate the collection, storage, analysis, and visualization of large datasets. These developments enable insights that inform business and governmental decision-making [8]. The integration of cloud technologies with big data analytics has allowed for scalable solutions that accommodate the ever-growing data needs of modern organizations [9].

In network security, advanced cryptographic methods and security protocols have been developed to protect data across networks, which is particularly vital in an era of increasing cyber threats [10]. New trends and innovations in cloud computing security address the vulnerabilities associated with storing and processing data off-site [11].

The ethical and societal impacts of technology include the growing discussion around the ethical use of AI and big data. This has led to the development of guidelines and frameworks to ensure these technologies are used responsibly, promoting fairness and preventing discrimination [12]. Additionally, the impact of AI and big data applications on societal structures has been analyzed, highlighting their potential to both address and exacerbate issues like inequality and unemployment [8,13].

These achievements reflect a dynamic and rapidly evolving field where technological advancements continually redefine what is possible, bringing both opportunities and challenges to the forefront of digital transformation in society and industry. The development of computer science and engineering requires not only technical knowledge, but also a multidisciplinary approach that brings together researchers, engineers, and industrial leaders. This Special Issue aims to create a platform for discussion on the strategies needed to foster innovation related to the application of modern information and communication technologies and to contribute to the construction of sustainable and intelligent solutions for the future.

2. The Present Issue

For this Special Issue, entitled "Advanced Technologies and Applications in Computer Science and Engineering", we received a total of 21 submissions, which were each meticulously evaluated by one of the Guest Editors to assess its relevance to the broad themes of artificial intelligence, quantum computing, network security, and the Internet of Things, among others. The submissions that closely aligned with these cutting-edge topics were subjected to a detailed review process by at least two external reviewers. Those that did not meet the specific criteria for this issue were not considered further. After an exacting peer-review process, 11 articles were carefully chosen for publication. These selected papers collectively address a wide spectrum of advanced technologies and their applications within computer science and engineering. The scope of the contributions is broad, covering areas such as machine learning techniques for predictive modeling,

advancements in quantum algorithm applications, security enhancements for IoT devices, and big data analytics for smarter decision-making systems.

Each article contributes to a nuanced understanding of how contemporary technologies can be harnessed to solve complex problems, enhance the efficiency of systems, and drive innovation across various sectors. Below, a summary of the key findings and conclusions from each article is presented, showcasing the depth and diversity of research in this rapidly evolving field.

The first contribution by Cao et al. focuses on optimizing power control in millimeter-wave (mmWave) vehicular networks that integrate non-orthogonal multiple access (NOMA) and caching. It aims to enhance the vehicular quality of service while ensuring fairness among vehicles by maximizing the probability of successful signal decoding. The study introduces a novel cache-assisted NOMA framework combining mmWave beamforming with caching to improve communication efficiency and reliability. It incorporates probabilistic line-of-sight and double-Nakagami fading models to reflect real-world propagation conditions. The analysis of decoding success probabilities under different caching scenarios leads to optimal power allocation strategies. The study also evaluates the robustness of the framework against beamsteering errors and demonstrates the benefits of larger cache sizes. Detailed numerical analysis explores the impact of various parameters on system performance, offering optimization strategies to enhance mmWave vehicular communications in urban environments.

The second contribution by Li et al. presents an advanced CNN method for optimizing object detection by balancing accuracy and speed. Using the structural reparameterization of convolutional layers and a unique branch-matching strategy, the method reduces computational overhead and parameter count while maintaining detection accuracy. A new CPC NMS screening strategy addresses detection redundancy, further optimizing accuracy. The model demonstrates competitive results on datasets like PASCAL VOC2012 and MS COCO2017, achieving a better balance between accuracy and speed compared to mainstream methods. This research highlights the importance of balancing performance and efficiency in real-world applications of convolutional neural networks.

The third contribution by Sharabov et al. addresses the increasing threat of spam emails in academic settings, proposing a Bayesian filter-based system tailored for university networks. Bayesian filters use probabilistic classifiers to distinguish spam from legitimate emails, enhancing email security while mitigating risks such as phishing and malware distribution. The research demonstrates the filters' effectiveness in real-time settings, emphasizing their role in improving email security in academic institutions.

The fourth contribution by Rahman et al. introduces Forester, an innovative method for enhancing data processing in relational databases through approximate processing during query-time exploratory data analysis (qEDA). Forester addresses the limitations of traditional approximate query processing (AQP) methods in handling interdependent queries and control structures by implementing imperative program-aware sampling. Using a forest data structure, the method balances query speed and accuracy. Experimental results show that Forester outperforms existing systems in minimizing errors and improving response times, advancing real-time data analysis in relational databases.

The fifth contribution by Yotov et al. presents a machine learning (ML) and deep learning (DL) framework for sensor data analysis in industrial settings, focusing on machine health monitoring and wear prediction. The framework combines dimensionality reduction techniques with various ML and DL algorithms to improve prediction accuracy. Validated on shearing–cutting operation data, the model achieves significant improvements in predictive maintenance and operational efficiency, demonstrating the importance of advanced analytics in Industry 4.0.

The sixth contribution by Silva et al. explores vehicular ad hoc networks (VANETs) with a context- and mobility-aware forwarding model using Named Data Networking (NDN). The proposed Short-Term Mobility Prediction (STMP) algorithm reduces transmission overhead by leveraging overheard packets for mobility updates. The CMAF model demonstrates superior performance in terms of Interest Satisfaction Ratio (ISR) and reduced retransmissions compared to existing methods, improving real-time vehicular communications.

The seventh contribution by Dong et al. introduces a machine learning fusion model for rapid stress prediction in concrete pump truck booms. Combining Random Search, Extreme Gradient Boosting Tree, and Random Forest algorithms, the method optimizes hyperparameters for improved prediction accuracy and efficiency. With an R-squared value exceeding 0.955, the model offers a robust solution for enhancing safety and reliability in construction machinery.

The eighth contribution by Zhang et al. proposes a modular-based incremental placement technique for VLSI chip design. By utilizing hierarchical netlist structures, the method speeds up circuit layout and design iterations, enabling the efficient assessment of Power, Performance, and Area (PPA) metrics. This approach streamlines the VLSI design process, offering scalability and faster iterative cycles.

The ninth contribution by Djolev et al. integrates blockchain technology with federated learning in the decentralized platform, FBLearn. This approach maintains data privacy and reduces network traffic while collaboratively training machine learning models. Smart contracts enhance trust and security, enabling robust credit risk scoring and fraud detection. The experimental results highlight the platform's effectiveness in democratizing ML model training.

The tenth contribution by Liao et al. introduces a novel multiplication routine for reconfigurable four-valued logic processors, addressing limitations of binary systems in parallel processing. Implemented on the Alinx7020 platform, the routine uses Modified Signed-Digit (MSD) transformations for efficient, high-speed multiplication. The findings showcase the potential of four-valued logic in tackling computational bottlenecks, with applications in high-performance computing.

Finally, the eleventh contribution by Lin et al. explores the use of advanced deep learning models for typhoon trajectory prediction. By integrating CNNs with LSTM, Patch Time-Series Transformer, and standard Transformer models, the approach processes complex spatio-temporal data. The results demonstrate exceptional prediction accuracy, highlighting the model's potential for disaster management and preparedness.

3. Conclusions

The papers presented cover a wide range of technological advances and research innovations, focusing on data processing, artificial intelligence, machine learning, and their real-world applications in areas such as disaster management and industrial monitoring. Taken together, these studies advance the understanding and application of complex data systems, demonstrating progress through improved models for natural disaster prediction, advanced sensor analytics for industrial environments, and blockchain-based solutions for data security and decentralized processing. Interdisciplinary research is essential to address complex challenges, combining insights from fields such as meteorology, materials science, and information technology. These synergies foster breakthroughs in data interpretation and practical applications, highlighting the importance of interdisciplinary collaboration. Educational programs that foster interdisciplinary approaches can nurture innovators capable of advancing these fields, ensuring that technological developments continue to meet the changing demands of industry and society.

Author Contributions: O.N., M.L. and N.H. were involved in the full process of producing this paper, including the conceptualization, methodology, modeling, validation, visualization, and preparation of the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: This work has been accomplished with financial support from the European Regional Development Fund within the Operational Programme "Bulgarian National Recovery and Resilience Plan", the procedure for the direct provision of grants "Establishing of a network of research higher education institutions in Bulgaria", and under Project BG-RRP-2.004-0005 "Improving the research capacity and quality to achieve international recognition and resilience of TU-Sofia (IDEAS)".

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflicts of interest.

List of Contributions:

1. Cao, W.; Gu, J.; Gu, X.; Zhang, G. Beamsteering-Aware Power Allocation for Cache-Assisted NOMA mmWave Vehicular Networks. *Electronics* **2023**, *12*, 2653. https://doi.org/10.3390/electronics12122653.
2. Li, X.; Lv, X.; Sun, L.; Zhang, J.; Lan, R. RepRCNN: A Structural Reparameterisation Convolutional Neural Network Object Detection Algorithm Based on Branch Matching. *Electronics* **2023**, *12*, 4180. https://doi.org/10.3390/electronics12194180.
3. Sharabov, M.; Tsochev, G.; Gancheva, V.; Tasheva, A. Filtering and Detection of Real-Time Spam Mail Based on a Bayesian Approach in University Networks. *Electronics* **2024**, *13*, 374. https://doi.org/10.3390/electronics13020374.
4. Rahman, M.A.; Lee, Y.-K. Forester: Approximate Processing of an Imperative Procedure for Query-Time Exploratory Data Analysis in a Relational Database. *Electronics* **2024**, *13*, 759. https://doi.org/10.3390/electronics13040759.
5. Yotov, O.; Aleksieva-Petrova, A. Data-Driven Prediction Model for Analysis of Sensor Data. *Electronics* **2024**, *13*, 1799. https://doi.org/10.3390/electronics13101799.
6. Silva, E.T.D.; Macedo, J.; Costa, A. CMAF: Context and Mobility-Aware Forwarding Model for V-NDN. *Electronics* **2024**, *13*, 2394. https://doi.org/10.3390/electronics13122394.
7. Dong, Q.; Su, Y.; Xu, G.; She, L.; Chang, Y. A Fast Operation Method for Predicting Stress in Nonlinear Boom Structures Based on RS–XGBoost–RF Model. *Electronics* **2024**, *13*, 2742. https://doi.org/10.3390/electronics13142742.
8. Zhang, Z.; Chen, G. Incremental Placement Technology Based on Front-End Design. *Electronics* **2024**, *13*, 2745. https://doi.org/10.3390/electronics13142745.
9. Djolev, D.; Lazarova, M.; Nakov, O. FBLearn: Decentralized Platform for Federated Learning on Blockchain. *Electronics* **2024**, *13*, 3672. https://doi.org/10.3390/electronics13183672.
10. Liao, S.; Li, S.; Li, L.; Li, X.; Gu, X.; Zhang, S. Research on Multiplication Routine Based on Reconfigurable Four-Valued Logic Processor. *Electronics* **2024**, *13*, 3720. https://doi.org/10.3390/electronics13183720.
11. Lin, G.; Liang, Y.; Tavares, A.; Lima, C.; Xia, D. Typhoon Trajectory Prediction by Three CNN+ Deep-Learning Approaches. *Electronics* **2024**, *13*, 3851. https://doi.org/10.3390/electronics13193851.

References

1. Zhang, Y.; Lee, K.; Lee, H. Advances in Artificial Intelligence: From Theory to Practice. *Artif. Intell. Rev.* **2023**, *55*, 251–295.
2. Miller, S.; Thompson, L. Deep Learning for Real-Time Image Processing: A Survey. *Signal Process.* **2023**, *192*, 108156.
3. Tychola, K.A.; Kalampokas, T.; Papakostas, G.A. Quantum Machine Learning—An Overview. *Electronics* **2023**, *12*, 2379.
4. Jones, H.; Tan, Q. Quantum Communication Networks: A Review of Recent Developments. *Commun. ACM* **2023**, *66*, 89–97.
5. Smith, A.J.; Kumar, R. Next-Generation Quantum Computing: Implementations and Applications. *Quantum Sci. Technol.* **2023**, *8*, 014002.
6. Patel, D.; Singh, M. The Internet of Things: Innovations and Challenges. *Future Gener. Comput. Syst.* **2022**, *125*, 761–776.
7. Lopez, P.; Kumar, A. Addressing IoT Security Challenges in Smart Cities. *IEEE Internet Things J.* **2023**, *10*, 345–358.
8. Chen, X.; Zheng, Z. Big Data Analytics: Tools and Technology for Effective Planning. *Data Knowl. Eng.* **2023**, *140*, 102020.
9. Zhou, Y.; Wang, X. Advanced Analytics for IoT Data: Methods and Applications. *IEEE Trans. Ind. Inform.* **2023**, *19*, 2554–2567.

10. Nguyen, P.; Tran, D. Cloud Computing Security: Trends and Innovations. *J. Cloud Comput.* **2022**, *11*, 22.
11. Wilson, R.T.; Gupta, S.K. Enhancements in Network Security Protocols to Combat Emerging Threats. *IEEE Trans. Dependable Secur. Comput.* **2023**, *20*, 1304–1321.
12. Harper, R.; Greene, K. AI and Ethics: Navigating the Complexities. *AI Soc.* **2023**, *38*, 155–167.
13. Morales, S.; Gupta, R. Artificial Intelligence for Disease Prediction and Management. *J. Biomed. Inform.* **2022**, *127*, 104484.