

Editorial

Engineering intelligence for a sustainable and resilient future: from foundations to real-world impact toward the SDGs

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ABSTRACT

The June 2026 issue of this journal presents a comprehensive body of research advancing efficient engineering intelligence from foundational theory to real-world deployment, with strong alignment to the Sustainable Development Goals (SDGs). A significant cluster addresses SDG 7 (Affordable and Clean Energy) and SDG 9 (Industry, Innovation, and Infrastructure) through innovations in microbial fuel cells, high-voltage insulation reliability, artificial intelligence (AI) based battery management systems, and energy-efficient LoRa/LoRaWAN frameworks. These works emphasize energy sustainability, system resilience, and infrastructure optimization. A second cluster focuses on advanced electronics, control, and communication systems, including memcapacitor design, hybrid model predictive control, reflectarray antennas, and embedded intelligence for autonomous systems, demonstrating efficiency-driven engineering across hardware and system levels. A dominant cluster highlights SDG 3 (Good Health and Well-being), with applications in medical imaging, sepsis detection, breast cancer classification, and mental health analysis, leveraging deep learning, transformers, and hybrid AI models. Finally, contributions aligned with SDG 4 (Quality Education) explore gamified learning systems, virtual reality adoption, and SDG-integrated educational information systems, while complementary studies in agriculture, finance, and Internet of Things (IoT) further demonstrate the societal impact of intelligent systems. Collectively, these works reinforce the role of efficient, scalable, and data-driven engineering in addressing global challenges.

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The accelerating convergence of intelligent computation, sustainable engineering, and real-world deployment is fundamentally reshaping the landscape of electrical and computer engineering. As global challenges related to energy security, public health, infrastructure resilience, and equitable access to education intensify, the role of engineering research is no longer confined to theoretical advancement. Instead, it increasingly demands the delivery of efficient, scalable, and societally impactful solutions that can be translated into practice across diverse environments and application domains. This shift reflects a broader transformation in the expectations placed on engineering disciplines, where relevance, applicability, and long-term impact are becoming central evaluation criteria.

In this evolving context, the June 2026 issue of the *International Journal of Electrical and Computer Engineering (IJECE)* presents a carefully curated collection of 47 rigorously reviewed papers that collectively reflect the emergence of engineering intelligence as a unifying paradigm. This paradigm integrates advances in artificial intelligence, data-driven modeling, system optimization, and hardware-aware design to address complex, real-world challenges. The contributions in this issue demonstrate not only methodological innovation but also a strong emphasis on efficiency, encompassing computational performance, energy consumption, system reliability, and deployment feasibility. Collectively, these works illustrate how engineering intelligence can bridge theoretical development and practical implementation in a meaningful and measurable way.

A defining characteristic of this issue is its explicit and implicit alignment with the Sustainable Development Goals (SDGs), particularly SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation, and Infrastructure), SDG 3 (Good Health and Well-being), and SDG 4 (Quality Education). These global priorities provide a meaningful framework for situating engineering research within broader societal objectives and long-term development agendas. The selected papers illustrate how cutting-edge technologies can contribute to cleaner energy systems, more resilient infrastructure, improved healthcare outcomes, and inclusive, technology-enhanced education. This alignment also reinforces the relevance of engineering research in addressing interdisciplinary challenges that extend beyond traditional technical boundaries.

Moreover, this issue highlights a notable shift from isolated technological advancements toward integrated, interdisciplinary solutions. Developments in energy systems are increasingly intertwined with intelligent control, communication technologies, and data-driven optimization approaches. Similarly, advances in artificial intelligence are being embedded into healthcare diagnostics, agricultural monitoring, and human-centered applications, demonstrating cross-domain applicability. This convergence reflects the growing recognition that addressing complex global challenges requires holistic system-level thinking, where multiple domains interact synergistically to produce robust and adaptive solutions.

Another important trend captured in this issue is the transition from laboratory-scale innovation to real-world deployment and validation. Several contributions explicitly consider constraints such as computational resources, energy efficiency, latency, and scalability, particularly in edge computing and embedded systems. This practical orientation ensures that proposed methods are not only theoretically sound but also implementable under realistic conditions. As a result, the research presented moves beyond proof-of-concept toward solutions that are ready for integration into operational environments.

In addition, the issue underscores the importance of robustness, interpretability, and reproducibility in modern engineering research. As systems become more complex and increasingly data-driven, ensuring transparency and reliability becomes essential, particularly in safety-critical and human-centered applications such as healthcare, autonomous systems, and public services. The inclusion of statistically validated methodologies, comparative analyses, and fairness-driven evaluation protocols reflects a maturing research landscape that prioritizes not only performance but also scientific rigor and trustworthiness. These qualities are essential for building confidence among stakeholders and facilitating broader adoption of advanced technologies.

Finally, the diversity of topics represented in this issue—from renewable energy systems and advanced electronics to artificial intelligence, IoT, and educational technologies—demonstrates the breadth and vitality of contemporary electrical and computer engineering research. Despite this diversity, a strong underlying coherence emerges, centered on the shared goal of advancing efficient engineering intelligence for sustainable and resilient development. The contributions collectively emphasize the importance of balancing innovation with efficiency, and performance with practicality. Together, they reaffirm the role of IJECE as a global platform for disseminating impactful research that bridges foundational theory and real-world application, contributing meaningfully to both scientific progress and societal well-being.

Sustainable Energy and Resilient Infrastructure (SDG 7 & SDG 9)

Sustainable energy systems and resilient infrastructure form the backbone of modern societies and are central to achieving long-term economic and environmental sustainability. The growing global demand for clean, reliable, and efficient energy solutions necessitates continuous innovation in power systems, materials, and system-level optimization. In this issue, several contributions directly address these challenges by advancing both theoretical and applied aspects of electrical and power engineering. These works collectively reflect the ongoing transition toward intelligent, adaptive, and sustainable energy ecosystems that align closely with SDG 7 and SDG 9.

A significant contribution in this domain is the exploration of alternative bioenergy sources through microbial fuel cell technologies utilizing sheep compost substrates. This study not only demonstrates the feasibility of bioelectricity generation in resource-constrained environments but also highlights the dual benefits of waste valorization and energy recovery. The findings reveal that optimized reactor configurations

can significantly enhance power output while influencing the physicochemical properties of the substrate. Such approaches illustrate how decentralized and low-cost energy solutions can support rural and remote communities, thereby contributing to more inclusive and sustainable energy infrastructures.

Complementing this work, research on high-voltage insulator performance under polluted conditions provides critical insights into the reliability of power transmission systems. By employing advanced simulation techniques to analyze electric field distributions, the study identifies key vulnerabilities associated with contamination and material interfaces. These findings are particularly relevant for regions exposed to harsh environmental conditions, where infrastructure reliability is frequently challenged. Enhancing the durability and performance of such components is essential for maintaining stable and resilient power grids in both urban and rural settings.

In addition, advancements in power electronics and control systems are evident through studies on hybrid dynamical systems and predictive control strategies. The application of mixed logical dynamical models and model predictive control to complex systems, such as multi-tank processes, demonstrates how intelligent control frameworks can optimize system performance under constraints. These approaches enable more efficient resource utilization and improved system stability, which are critical for modern industrial and energy applications. Furthermore, such control methodologies provide a foundation for integrating renewable energy sources into existing power systems with greater reliability and flexibility.

Energy efficiency is also addressed at the system and network levels through research on optimized communication protocols for LoRaWAN-based Internet of Things (IoT) systems. The proposed energy-aware MAC layer protocol and routing strategies significantly improve throughput, reduce latency, and minimize energy consumption in large-scale networks. These improvements are essential for supporting smart infrastructure applications, including environmental monitoring, smart cities, and industrial automation. By enhancing communication efficiency, these contributions support the broader development of scalable and energy-efficient digital infrastructure.

Another important dimension of sustainable infrastructure is the optimization of sensing and communication in resource-constrained environments. The study on energy-aware scheduling of inertial measurement units (IMUs) in wearable LoRa systems demonstrates how adaptive sensing strategies can balance accuracy, responsiveness, and power consumption. By leveraging quaternion-based feature extraction and dynamic scheduling, the proposed framework extends device lifetime while maintaining reliable performance. This work is particularly relevant for applications in healthcare monitoring, smart mobility, and human-centric IoT systems, where energy efficiency is a critical design constraint.

At the materials and device level, research on memcapacitor emulators and advanced electronic components contributes to the development of energy-efficient circuit designs. The proposed multiplier-less memcapacitor emulator enables low-complexity implementation while supporting applications in neuromorphic systems and frequency-selective circuits. Such innovations are essential for reducing power consumption in next-generation electronic systems, particularly in edge computing and embedded applications. These developments highlight the importance of hardware-level efficiency in achieving broader sustainability goals.

Furthermore, the issue includes research on advanced antenna designs, such as reflectarray unit cells, which contribute to efficient electromagnetic wave manipulation in communication systems. Optimizing antenna performance in terms of bandwidth, return loss, and phase response is crucial for enhancing wireless communication efficiency and reliability. These advancements support the development of high-performance communication infrastructure required for modern digital ecosystems. In turn, robust communication systems are a key enabler of smart grids, intelligent transportation, and interconnected industrial systems.

Finally, the collective contributions in this section underscore the importance of integrating energy innovation with intelligent system design to build resilient and sustainable infrastructure. From bioenergy generation and power system reliability to communication efficiency and hardware optimization, the presented works demonstrate a multi-layered approach to addressing energy challenges. This holistic perspective is essential for achieving long-term sustainability, as it considers not only energy production but also transmission, utilization, and system integration. Together, these studies provide a comprehensive foundation for advancing engineering solutions that are aligned with global sustainability priorities and future-ready infrastructure development.

Advanced Electronics, Control, and Communication Systems

Advancements in electronics, control engineering, and communication systems continue to play a pivotal role in enabling intelligent and interconnected technological ecosystems. These domains provide the essential building blocks for modern applications ranging from industrial automation to next-generation wireless communication networks. In this issue, several contributions highlight innovative approaches to circuit design, system modeling, and communication efficiency, reflecting the increasing complexity and

integration of engineering systems. Collectively, these works emphasize not only performance enhancement but also efficiency, scalability, and adaptability in diverse operational environments.

A key contribution in advanced electronics is the development of a multiplier-less memcapacitor emulator, which offers a compact and efficient solution for implementing memory-based circuit elements. By leveraging current conveyors and operational transconductance amplifiers, the proposed design reduces hardware complexity while maintaining functional accuracy. The emulator is validated through simulation and experimental implementation, demonstrating its applicability in frequency-selective circuits and neuromorphic systems. This work highlights the growing importance of memory-enabled circuit components in supporting adaptive and intelligent electronic systems.

In the area of electromagnetic and communication system design, research on reflectarray antennas presents a comparative analysis of novel unit cell geometries. By evaluating different patch configurations within the X-band frequency range, the study provides insights into optimizing return loss, bandwidth, and phase response characteristics. The findings reveal that geometric variations significantly influence antenna performance, offering pathways for further enhancement in large-scale array designs. Such advancements are essential for improving the efficiency and reliability of modern wireless communication systems, particularly in high-frequency applications.

Control systems engineering is further advanced through the application of hybrid modeling and predictive control techniques to complex dynamical systems. The use of mixed logical dynamical frameworks combined with model predictive control enables the effective handling of systems that exhibit both continuous and discrete behaviors. The implementation on a three-tank spherical system demonstrates improved stability, constraint handling, and tracking performance under varying operating conditions. These results underscore the potential of advanced control methodologies in optimizing industrial processes and enhancing system robustness.

Complementing these developments, research on radar-based gesture recognition introduces an innovative approach to human-machine interaction in unmanned aerial vehicle (UAV) control. By utilizing radar signals and machine learning classifiers, the proposed system enables robust gesture recognition independent of lighting conditions and visual obstructions. The use of lightweight features and efficient classifiers ensures high accuracy while maintaining low computational complexity. This approach highlights the potential of alternative sensing modalities in developing intuitive and reliable control interfaces for autonomous systems.

Another important contribution in this section focuses on communication efficiency and network-level optimization through energy-aware protocols and intelligent routing strategies. The integration of adaptive MAC layer design with machine learning-based routing mechanisms enhances throughput, reduces latency, and improves overall network reliability. These advancements are particularly relevant for IoT-based systems, where large-scale connectivity and resource constraints present significant challenges. By addressing these issues, the research supports the development of scalable and efficient communication infrastructures.

In addition, hardware-aware optimization is explored through comparative studies of lightweight convolutional neural networks deployed on resource-constrained platforms such as Raspberry Pi. These studies highlight the trade-offs between computational efficiency, memory usage, and real-time performance in embedded systems. The findings demonstrate that models with superior theoretical accuracy do not always translate to stable real-world performance, emphasizing the importance of system-level evaluation. Such insights are critical for the practical deployment of intelligent systems in edge computing environments.

Furthermore, research on sensing and data acquisition systems, including wearable IMU-based frameworks, illustrates the importance of efficient signal processing and adaptive system design. By optimizing sampling strategies and feature extraction processes, these systems can achieve a balance between accuracy and energy consumption. This is particularly important in applications that require continuous monitoring and real-time data transmission. The integration of sensing, processing, and communication within a unified framework reflects the increasing convergence of multiple engineering domains.

Finally, the contributions in this section collectively demonstrate how advancements in electronics, control, and communication systems are driving the evolution of intelligent engineering solutions. These works highlight the importance of integrating hardware innovation, algorithmic intelligence, and system-level optimization to address emerging challenges. By focusing on efficiency, adaptability, and real-world applicability, the research presented provides valuable insights for the design of next-generation engineering systems. Together, they reinforce the critical role of these foundational domains in enabling sustainable, resilient, and intelligent technological infrastructures.

Artificial Intelligence for Health and Societal Well-being (SDG 3)

Artificial intelligence (AI) is increasingly transforming healthcare and societal systems by enabling data-driven decision-making, early diagnosis, and personalized interventions. The integration of machine

learning, deep learning, and advanced data analytics into health-related applications is reshaping how diseases are detected, monitored, and managed. In this issue, several contributions demonstrate how AI-driven approaches can address critical challenges in medical imaging, disease prediction, mental health analysis, and biomedical data interpretation. These works collectively highlight the growing role of intelligent systems in improving health outcomes and supporting broader societal well-being, in alignment with SDG 3.

A prominent contribution in medical imaging is the development of a hybrid framework combining convolutional neural networks and vision transformers for multimodal image registration. By leveraging the global context modeling capabilities of transformers alongside the local feature extraction strength of CNNs, the proposed approach improves the accuracy of aligning prostate MRI and transrectal ultrasound images. This integration enables more precise diagnosis and treatment planning, particularly in complex clinical scenarios where multimodal data is essential. The results demonstrate that combining complementary AI architectures can overcome limitations of individual methods and enhance overall system performance.

In a related domain, deep learning-based approaches for breast cancer classification are explored through a comparative evaluation of optimized convolutional neural network architectures. The study emphasizes fairness-driven experimental design, ensuring that comparisons between models such as ResNet-50 and EfficientNet-B0 are conducted under consistent and statistically validated conditions. The findings reveal that different architectures exhibit complementary strengths depending on diagnostic requirements, such as screening versus classification tasks. This work underscores the importance of methodological rigor and reproducibility in developing reliable computer-aided diagnosis systems.

Beyond imaging, AI is also applied to the detection of critical health conditions through biomarker analysis and predictive modeling. The study on sepsis detection utilizes machine learning and deep learning techniques to identify immune-related gene subsets with high diagnostic relevance. By combining feature selection strategies with classification models, the proposed approach achieves high accuracy and sensitivity, demonstrating its potential for early disease detection. Early identification of such life-threatening conditions is crucial for improving patient survival rates and reducing healthcare burdens.

Mental health analysis represents another important application area addressed in this issue. The integration of fine-tuned language models, such as transformer-based architectures, with optimization techniques like genetic algorithms enables more accurate detection of depression from social media data. By comparing multiple vectorization and classification methods, the study demonstrates the effectiveness of combining advanced natural language processing with intelligent optimization strategies. These approaches provide scalable solutions for monitoring mental health trends and supporting early intervention strategies in digital environments.

AI-driven techniques are also applied in the context of human behavior and emotion recognition, which have implications for both healthcare and human-computer interaction. Research on facial emotion recognition explores the optimization of transfer learning models under limited data conditions, providing insights into model selection, data augmentation strategies, and fine-tuning approaches. The findings highlight the importance of adapting deep learning architectures to domain-specific constraints to achieve optimal performance. Such systems can be integrated into assistive technologies, educational tools, and healthcare monitoring systems to enhance user experience and well-being.

In addition, the application of AI extends to biomedical signal processing and diagnostic systems, such as fault classification in mechanical components relevant to medical devices and rehabilitation technologies. By comparing machine learning models including decision trees and neural networks, the study demonstrates that simpler and more interpretable models can achieve competitive performance. This insight is particularly valuable in safety-critical applications, where transparency and reliability are essential. The balance between model complexity and interpretability remains a key consideration in deploying AI systems in real-world healthcare environments.

Furthermore, AI technologies are increasingly contributing to broader societal applications that indirectly support health and well-being. For example, research on sentiment analysis of public feedback provides valuable insights into user experiences and service quality, which can inform improvements in public and institutional services. Similarly, AI-based systems for gesture recognition and human-machine interaction contribute to safer and more intuitive control mechanisms in assistive and autonomous systems. These contributions highlight the comprehensive impact of AI beyond clinical settings, extending into everyday life and societal infrastructure.

Finally, the works presented in this section collectively demonstrate the transformative potential of AI in advancing health and societal well-being. By integrating advanced algorithms with domain-specific knowledge, these studies provide robust and scalable solutions to complex challenges. The emphasis on accuracy, efficiency, interpretability, and real-world applicability ensures that these innovations can be effectively translated into practice. Together, they reinforce the critical role of AI as a key enabler in achieving sustainable and inclusive health outcomes in the modern era.

Intelligent Data-Driven Systems and Optimization

The rapid growth of data availability and computational capabilities has positioned intelligent data-driven systems at the forefront of modern engineering innovation. These systems leverage machine learning, statistical modeling, and optimization techniques to extract meaningful insights, improve predictive accuracy, and support informed decision-making across diverse domains. In this issue, several contributions explore novel methodologies for data processing, feature selection, clustering, and forecasting, reflecting the increasing importance of data-centric approaches in engineering practice. Collectively, these works highlight how intelligent optimization strategies can enhance system performance, efficiency, and adaptability in complex and dynamic environments.

A notable contribution in this domain is the development of a deterministic centroid initialization method, variance-k-means++, which addresses the limitations of randomness in traditional clustering algorithms. By incorporating statistical measures such as mean and variance to generate pseudo-centroids, the proposed method improves clustering stability and reduces the number of iterations required for convergence. Experimental results demonstrate superior performance compared to conventional k-means and k-means++ approaches, particularly in terms of the Davies–Bouldin Index and convergence speed. This advancement underscores the importance of initialization strategies in unsupervised learning and their impact on the reliability of clustering outcomes.

In the area of time-series analysis and forecasting, hybrid deep learning models are introduced to address the inherent complexity of nonlinear and dynamic datasets. The integration of bidirectional long short-term memory (BiLSTM) networks with transformer architectures enables the capture of both local temporal dependencies and global contextual relationships. By embedding convolutional layers to enhance feature extraction, the proposed model achieves improved forecasting performance across multiple datasets. Such hybrid architectures demonstrate the potential of combining complementary learning paradigms to overcome the limitations of individual models in complex prediction tasks.

Economic forecasting is further explored through comparative analyses of machine learning approaches for modeling gross domestic product (GDP) growth. By evaluating methods such as naïve models, smoothing techniques, and k-nearest neighbors, the study provides valuable insights into the strengths and limitations of different forecasting strategies. The results indicate that machine learning-based approaches can offer improved predictive accuracy, supporting more informed economic planning and policy development. This work highlights the broader applicability of data-driven methods beyond traditional engineering domains, extending into socio-economic analysis and decision-making.

Optimization techniques are also prominently featured in this section, particularly in the context of feature selection and model enhancement. The integration of optimization algorithms, such as genetic algorithms and entropy-based methods, with machine learning models enables more efficient exploration of parameter spaces and improved model performance. For instance, the use of optimization-driven feature selection in materials science applications demonstrates how data-driven approaches can accelerate the discovery and evaluation of novel materials. These methods reduce reliance on costly experimental procedures while maintaining high levels of predictive accuracy.

In addition, the application of machine learning to classification and pattern recognition tasks is evident in studies focusing on agricultural and environmental monitoring. The use of advanced architectures, including transformer-based models and convolutional neural networks, combined with data augmentation techniques such as generative adversarial networks, enhances classification robustness and generalization. These approaches are particularly valuable in addressing challenges such as class imbalance and limited data availability. By improving the reliability of classification systems, these contributions support practical applications in smart agriculture and environmental sustainability.

Another important aspect of intelligent data-driven systems is their deployment in resource-constrained and real-time environments. Research on lightweight models and efficient algorithms demonstrates how optimization can be tailored to meet the constraints of edge devices and embedded systems. By balancing computational efficiency with predictive performance, these systems enable real-time decision-making in applications such as autonomous systems, IoT networks, and mobile platforms. This focus on practical deployment ensures that data-driven innovations can be effectively translated into real-world solutions.

Furthermore, the integration of data-driven techniques with domain-specific knowledge enhances the interpretability and applicability of machine learning models. Studies in this issue emphasize the importance of combining statistical validation, domain expertise, and algorithmic innovation to achieve robust and trustworthy outcomes. This approach is particularly important in applications where decision-making has significant real-world implications, such as healthcare, energy systems, and economic planning. The synergy between data and domain knowledge represents a key direction for future research in intelligent systems.

Finally, the contributions in this section collectively demonstrate the transformative potential of intelligent data-driven systems and optimization techniques in modern engineering. By addressing challenges

related to data quality, model performance, and computational efficiency, these works provide a comprehensive foundation for advancing data-centric innovation. The emphasis on scalability, robustness, and real-world applicability ensures that these approaches can support a wide range of applications across multiple domains. Together, they reinforce the critical role of data-driven intelligence in shaping the future of engineering and technology.

Smart Agriculture, IoT, and Edge Intelligence

The convergence of smart agriculture, Internet of Things (IoT), and edge intelligence is rapidly transforming how data is collected, processed, and utilized in real-world environments. These technologies enable continuous monitoring, decentralized decision-making, and efficient resource utilization, which are essential for addressing challenges in agriculture, environmental sustainability, and industrial automation. In this issue, several contributions highlight how intelligent sensing, edge computing, and machine learning can be integrated to support scalable and energy-efficient systems. Collectively, these works demonstrate the growing importance of distributed intelligence in enabling responsive and adaptive solutions across diverse application domains.

A significant application area is smart agriculture, where advanced machine learning models are employed to improve crop health monitoring and disease detection. The integration of generative adversarial networks with vision transformers enables the creation of balanced datasets and robust classification models for rice leaf disease detection. By addressing class imbalance and enhancing generalization, the proposed approach achieves high accuracy even in real-field conditions. This work illustrates how combining data augmentation with advanced learning architectures can significantly improve the reliability of agricultural monitoring systems.

Complementing this research, the application of optimized deep learning frameworks for chili plant disease classification demonstrates the effectiveness of combining lightweight architectures with advanced optimization techniques. The integration of MobileNetV2 with entropy-based whale optimization enables efficient feature selection and improved classification accuracy while maintaining computational efficiency. Such approaches are particularly suitable for deployment on edge devices, where processing power and energy resources are limited. These contributions highlight the potential of intelligent systems to support precision agriculture and sustainable farming practices.

Edge intelligence is further explored through studies focusing on resource-constrained platforms and real-time decision-making systems. Research on lightweight convolutional neural networks deployed on embedded devices, such as Raspberry Pi-based autonomous systems, demonstrates the importance of balancing accuracy with computational efficiency. The findings reveal that models optimized for hardware constraints can achieve stable and reliable performance in real-world scenarios, even when operating under limited resources. This emphasizes the need for hardware-aware design strategies in developing practical AI solutions.

In addition to vision-based systems, alternative sensing modalities are also investigated to enhance robustness and flexibility in IoT applications. The use of radar-based gesture recognition for controlling unmanned aerial vehicles introduces a non-contact and lighting-independent interaction mechanism. By leveraging time-frequency features and lightweight machine learning classifiers, the proposed system achieves high recognition accuracy with minimal computational overhead. Such innovations expand the scope of human-machine interaction in smart environments and autonomous systems.

Energy efficiency remains a central concern in IoT and edge computing systems, particularly in large-scale and long-range deployments. The development of energy-aware scheduling frameworks for wearable systems using inertial measurement units demonstrates how adaptive sensing and communication strategies can extend device lifetime. By optimizing sampling rates, feature extraction, and transmission decisions, the proposed approach balances accuracy and energy consumption effectively. This work underscores the importance of intelligent resource management in ensuring the sustainability of IoT ecosystems.

Furthermore, communication efficiency and network optimization play a critical role in supporting large-scale IoT deployments. Research on energy-efficient MAC layer protocols and optimized routing algorithms for LoRaWAN networks highlights how intelligent communication strategies can improve throughput, reduce latency, and enhance reliability. These advancements are essential for enabling robust connectivity in smart agriculture, environmental monitoring, and industrial applications. By addressing both network-level and device-level challenges, these contributions support the development of scalable and resilient IoT infrastructures.

Another important aspect of this domain is the integration of data processing, sensing, and decision-making at the edge. By moving computation closer to data sources, edge intelligence reduces latency, enhances privacy, and improves system responsiveness. The studies presented in this issue demonstrate how distributed architectures can effectively support real-time analytics and adaptive control in dynamic environments. This paradigm shift from centralized to decentralized intelligence is a key enabler of next-generation smart systems.

Finally, the contributions in this section collectively highlight the transformative potential of integrating smart agriculture, IoT, and edge intelligence. By combining advanced sensing technologies, machine learning algorithms, and efficient communication protocols, these works provide comprehensive solutions for real-world challenges. The emphasis on scalability, energy efficiency, and deployment feasibility ensures that these innovations can be effectively implemented in practical settings. Together, they reinforce the critical role of distributed and intelligent systems in advancing sustainable development and resilient technological ecosystems.

Education, Human-Centered Systems, and SDG 4

Education and human-centered systems play a crucial role in shaping inclusive, equitable, and sustainable societies, as emphasized by SDG 4. In the context of rapid digital transformation, the integration of advanced technologies into educational environments has become essential for enhancing learning experiences and outcomes. This issue presents several contributions that explore the intersection of education, technology adoption, and user-centered system design. These works collectively demonstrate how engineering solutions can support more effective, engaging, and accessible learning ecosystems.

A key contribution in this domain is the development of a theoretical model for integrating Sustainable Development Goals into educational information systems. By employing a design science research methodology, the study proposes a structured framework that enables schools to systematically plan, monitor, and evaluate sustainability-oriented activities. The implementation of a web-based prototype demonstrates the practical feasibility of embedding SDG principles into school management systems. This work highlights the potential of information technology to facilitate data-driven decision-making and promote sustainability awareness in educational institutions.

Gamification in education is further explored through studies analyzing learner engagement and interaction in massive open online courses (MOOCs). By applying structural equation modeling techniques, these studies investigate the relationships between engagement, interaction, and learning outcomes in gamified learning environments. The findings indicate that both engagement and interaction significantly influence learners' performance and satisfaction. These insights provide valuable guidance for designing more effective and motivating online learning platforms, particularly in technical and vocational education and training contexts.

In addition, research on the adoption of virtual reality technologies in education highlights the importance of user acceptance and behavioral intention in technology integration. By utilizing established theoretical models of technology acceptance, the study examines factors influencing students' willingness to adopt virtual reality-based learning systems. The results demonstrate that perceived usefulness, ease of use, and engagement significantly impact adoption decisions. This work underscores the need to consider human factors and user experience when implementing advanced educational technologies.

Human-centered design is also reflected in studies focusing on user perception, feedback analysis, and service quality evaluation. The application of sentiment analysis techniques to social media data provides insights into user experiences and expectations regarding institutional services. By identifying patterns in user feedback, such approaches enable organizations to improve service delivery and enhance user satisfaction. This demonstrates how data-driven methods can support continuous improvement in human-centered systems beyond traditional educational settings.

Furthermore, the integration of artificial intelligence and data analytics into educational systems enables more personalized and adaptive learning experiences. By leveraging machine learning techniques, educational platforms can tailor content, assess learner progress, and provide targeted interventions. This capability is particularly important in diverse learning environments, where students have varying needs, backgrounds, and learning styles. The contributions in this issue highlight how intelligent systems can enhance both the effectiveness and inclusivity of education.

Another important aspect of education in the digital era is the development of scalable and accessible learning infrastructures. Technologies such as cloud computing, IoT, and edge systems enable the delivery of educational content across geographically distributed regions. These infrastructures support remote learning, collaborative environments, and real-time interaction, which are essential for modern education systems. By addressing challenges related to accessibility and scalability, these technologies contribute to reducing educational disparities.

Finally, the works presented in this section collectively emphasize the importance of aligning technological innovation with human needs and societal goals. By integrating engineering solutions with pedagogical principles and user-centered design, these studies contribute to the development of more effective and sustainable educational systems. The emphasis on engagement, accessibility, and adaptability ensures that these innovations can support diverse learners and evolving educational demands. Together, they reinforce the

critical role of education and human-centered systems in achieving sustainable development and fostering a knowledge-based society.

Discussion: Toward Efficient Engineering Intelligence

The collection of papers in this issue collectively illustrates a significant paradigm shift toward what can be described as efficient engineering intelligence, which strongly aligns with the Sustainable Development Goals (SDGs). This paradigm emphasizes not only the integration of artificial intelligence and advanced computational techniques into engineering systems but also their optimization for real-world deployment with societal impact. In particular, these developments directly support SDG 9 (Industry, Innovation, and Infrastructure) by enabling more intelligent, scalable, and resilient engineering systems. At the same time, the emphasis on energy efficiency and sustainable system design contributes to SDG 7 (Affordable and Clean Energy), ensuring that technological progress remains aligned with environmental and resource constraints.

A key observation emerging from this issue is the convergence of multiple technological domains into unified, interdisciplinary solutions that support global sustainability targets. Advances in energy systems, intelligent control, healthcare analytics, and educational technologies demonstrate clear alignment with SDG 3 (Good Health and Well-being) and SDG 4 (Quality Education). These convergences are not purely technical but also reflect a systemic effort to integrate engineering intelligence into socially meaningful applications. By combining artificial intelligence, IoT, and data-driven optimization, the research collectively contributes to more inclusive, efficient, and socially responsive systems.

Another important dimension of efficient engineering intelligence is deployment-aware and sustainability-oriented design, which directly supports SDG 9 and SDG 7. Several studies explicitly address constraints such as energy consumption, computational efficiency, and hardware limitations, ensuring that proposed solutions are viable in real-world environments. Lightweight AI models, edge computing frameworks, and energy-aware communication protocols demonstrate how engineering systems can be both high-performing and resource-efficient. These contributions highlight the importance of designing technologies that are not only innovative but also sustainable and scalable across diverse infrastructure contexts.

The role of data-driven methodologies is also closely linked to SDG 3 and SDG 9, particularly in healthcare diagnostics, environmental monitoring, and intelligent decision-support systems. Machine learning models, predictive analytics, and optimization techniques enable more accurate and timely insights that can improve health outcomes and support infrastructure planning. However, the issue also highlights challenges related to data quality, fairness, and interpretability, which are critical for ensuring trustworthy applications in sensitive domains. Addressing these challenges is essential for achieving reliable and equitable technological systems that serve societal needs effectively.

In addition, efficiency across algorithmic, system, and infrastructural levels contributes directly to SDG 7 and SDG 9, particularly in energy systems and communication networks. Algorithmic improvements such as feature selection and hybrid modeling enhance computational efficiency, while system-level innovations improve real-time responsiveness and reliability. At the infrastructural level, advancements in IoT networks, smart grids, and distributed systems enable scalable and energy-efficient deployment of intelligent technologies. This multi-layered optimization approach ensures that engineering solutions are aligned with sustainability and industrial innovation goals.

Human-centered design considerations strongly support SDG 3 and SDG 4, particularly in healthcare, education, and interactive systems. The integration of user behavior modeling, engagement analysis, and adaptive learning systems ensures that technological solutions are responsive to human needs. In education, intelligent platforms and gamified systems enhance accessibility and learning effectiveness, contributing directly to inclusive and quality education outcomes. Similarly, healthcare applications improve early diagnosis, mental health monitoring, and personalized treatment, reinforcing the societal impact of engineering intelligence.

Furthermore, robustness, fairness, and reproducibility are essential for achieving sustainable outcomes aligned with all four targeted SDGs. Ensuring transparency in AI models and validating performance across diverse datasets helps build trust in critical applications such as healthcare and infrastructure systems. These practices are particularly important for SDG 3 and SDG 9, where system reliability and ethical considerations directly affect human safety and industrial performance. The emphasis on rigorous evaluation frameworks reflects the maturity of current engineering research in addressing real-world complexity.

Another key insight is the shift toward decentralized and distributed intelligence, which supports SDG 7 and SDG 9 by improving energy efficiency and infrastructure resilience. Edge computing, IoT systems, and distributed processing reduce latency and energy consumption while enhancing system autonomy. These technologies are particularly valuable in remote and resource-constrained environments, where centralized systems are impractical. The decentralization of intelligence thus represents a critical step toward more sustainable and adaptive engineering ecosystems.

Finally, the discussion underscores that efficient engineering intelligence is fundamentally aligned with the SDGs as a guiding framework for future research and development. The integration of AI, IoT, optimization, and human-centered design ensures that engineering solutions are not only technically advanced but also socially and environmentally responsible. By simultaneously addressing SDG 3, SDG 4, SDG 7, and SDG 9, the contributions in this issue demonstrate a coherent vision for sustainable technological progress. Collectively, they provide a strong foundation for future research aimed at building intelligent, resilient, and inclusive engineering systems worldwide.

Conclusion

This editorial has presented a synthesis of 47 research articles that collectively advance the concept of efficient engineering intelligence in alignment with the Sustainable Development Goals (SDGs). Across diverse domains including energy systems, communications, electronics, artificial intelligence, healthcare, agriculture, and education, the studies consistently demonstrate strong contributions to SDG 7 (Affordable and Clean Energy) and SDG 9 (Industry, Innovation, and Infrastructure) through energy-efficient designs, intelligent control systems, IoT-based infrastructures, and optimized communication and power networks. In parallel, several works directly support SDG 3 (Good Health and Well-being) via machine learning and deep learning applications in medical diagnosis, disease detection, and mental health analysis, while others contribute to SDG 4 (Quality Education) through gamified learning systems, virtual reality adoption, and intelligent educational platforms. Collectively, these contributions highlight a clear transition toward integrated, data-driven, and sustainable engineering systems that extend beyond theoretical development into real-world impact.

Looking forward, the findings of these 47 articles strongly indicate several important research directions. First, there is a growing need for explainable, reliable, and ethically aligned AI systems, particularly for healthcare and societal applications under SDG 3. Second, future engineering systems must prioritize energy efficiency, lightweight design, and edge deployment to support scalable infrastructures aligned with SDG 7 and SDG 9. Third, intelligent educational technologies and human-centered systems should be further enhanced to improve accessibility and learning quality under SDG 4. Finally, deeper integration of artificial intelligence, optimization techniques, and distributed systems across multiple engineering domains will be essential to build resilient, adaptive, and sustainable infrastructures. Overall, this issue confirms that engineering intelligence is becoming a central enabler of sustainable development across technology and society.