Editorial

Intelligent systems, AI/ML, IoT, smart grids, robotics, healthcare, and emerging innovations

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ABSTRACT

This editorial discusses the latest trends and emerging ideas in electrical and computer engineering. It emphasises how intelligent systems, artificial intelligence and machine learning (AI/ML), the internet of things (IoT), smart grids, robotics, and healthcare technologies are transforming the field. The issue highlights the integration of data-driven intelligence, adaptive control, and real-time monitoring across various applications, including industrial automation, energy management, environmental monitoring, and personalised healthcare. Key themes encompass the development of AI/ML models for predictive analytics, IoT-enabled cyber-physical systems for autonomous decision-making, robotics for both human assistance and industrial operations, and smart grids aimed at achieving sustainable and resilient energy distribution. Furthermore, emerging innovations tackle challenges related to scalability, interpretability, energy efficiency, security, and the ethical deployment of intelligent technologies. By examining these interconnected domains, the editorial underscores the increasing interplay between computational intelligence, connected systems, and societal needs, while offering suggestions for future research directions and considering the potential impact of these technologies on global industries and human well-being.

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The landscape of electrical and computer engineering is progressing at an extraordinary rate, propelled by the convergence of intelligent systems, artificial intelligence (AI), machine learning (ML), the internet of things (IoT), smart grids, robotics, and healthcare technologies. As digital and physical systems increasingly merge, researchers and practitioners are harnessing these innovations to tackle complex challenges, enhance operational efficiency, and improve human wellbeing. Volume 16, Number 2, of the International Journal of Electrical and Computer Engineering (IJECE) reflects this transformative period, emphasising both the depth and interdisciplinary nature of current research.

This issue showcases the convergence of technologies at the intersection of data, intelligence, and connectivity, exemplifying the practical application of theoretical advancements. Several recurring themes emerge across the featured studies: the increasing sophistication of AI/ML models, the proliferation of IoT-enabled cyber-physical systems, the evolution of smart grids toward predictive and self-regulating architectures, and the expanding influence of robotics and intelligent healthcare solutions. Together, these trends illustrate a shift from isolated technological innovations to holistic, integrated systems capable of adapting, learning, and operating autonomously in dynamic environments.

Intelligent Systems and AI/ML: From Perception to Decision-Making

Intelligent systems and AI frameworks form the foundation of the advances discussed in this issue. Machine learning and deep learning now enable a diverse array of applications, ranging from real-time decision-making and predictive maintenance to healthcare diagnostics and environmental monitoring. AI's capability to analyse complex, high-dimensional datasets empowers systems to identify patterns, anticipate anomalies, and deliver actionable insights that traditional methods often fall short of. The integration of AI into physical systems and embedded devices facilitates adaptive, context-aware automation, allowing machines to respond dynamically to shifting environments. These developments highlight the transformative potential of AI/ML in connecting data collection, comprehension, and autonomous action.

Hybrid architectures that combine convolutional neural networks (CNNs), recurrent neural networks (RNNs), bidirectional LSTMs, and transformer-based models are becoming increasingly prevalent. Such architectures enhance both detailed feature extraction and long-range contextual understanding, thereby improving decision-making across various domains. Explainable AI techniques are particularly vital in critical fields such as healthcare, environmental monitoring, and autonomous systems, ensuring that outputs are interpretable and actionable. Multimodal learning, which allows AI models to process text, images, audio, and sensor data simultaneously, further improves predictive accuracy and robustness, especially in noisy or incomplete real-world scenarios.

AI/ML models are now assessed not only on performance metrics like accuracy or F1-score but also on transparency, efficiency, and robustness. Ethical, human-centred, and sustainable design has emerged as a central concern, especially for applications with significant stakes. Optimisation for computational efficiency supports deployment on edge devices and IoT-enabled systems, making intelligent automation feasible in real-time or resource-constrained settings. These trends herald a paradigm shift where we evaluate intelligence not only by predictive performance, but also by adaptability, sustainability, and societal impact.

IoT and Smart Grids: Intelligent Connectivity

The IoT has transformed the interaction between physical systems and the digital world. In this issue, IoT emerges as a key enabler for real-time monitoring, adaptive control, and autonomous decision-making. By integrating sensing, communication, and actuation capabilities, IoT allows systems to respond intelligently and efficiently to dynamic conditions. When combined with AI and predictive analytics, IoT systems not only react but also anticipate and optimise future operations, improving performance across industrial, environmental, and energy applications.

Smart grids exemplify the power of IoT integration in energy systems. Embedded sensors, smart meters, and predictive algorithms allow grids to balance supply and demand, integrate renewable sources, and perform predictive maintenance. Hybrid cloud fog architectures support efficient data processing, while edge computing ensures fast, localised decision-making. IoT-enabled grids can also incorporate distributed energy resources such as solar panels and storage units, creating resilient and decentralised energy networks. These intelligent grids improve operational efficiency and reduce energy waste, lower carbon footprints, and support sustainable energy goals.

IoT enables user-centric approaches that shift from pre-programmed automation to flexible, learning-based infrastructures that can self-optimize. By integrating smart sensors, wearable devices, and mobile interfaces, users gain real-time insights and control, improving safety, comfort, and operational efficiency. Looking forward, the combination of IoT, AI, and predictive analytics is poised to accelerate the development of adaptive, self-healing, and context-aware infrastructures, shaping the future of intelligent connectivity.

Robotics: Adaptive and Intelligent Machines

Robotics continues to transform industrial, clinical, and service sectors. Advances in control systems, sensor integration, and machine learning have produced robots capable of operating autonomously in dynamic, unstructured environments. Adaptive control strategies, including sliding-mode control and time-delay estimation, enable robots to maintain precision, stability, and resilience despite uncertainties or perturbations. Developments in soft robotics and compliant actuators further expand potential applications by allowing safe interaction with delicate objects and humans.

Modern robotics utilises energy-aware planning, sensor fusion, and predictive algorithms to optimise performance and efficiency. AI lets robots learn from their interactions, change to fit different environments, and work safely with people. The convergence of robotics with IoT, wearables, and cloud-based analytics extends applications to healthcare, rehabilitation, and assisted living, enabling real-time monitoring, adaptive therapy, and personalised assistance. These intelligent systems respond to changing conditions, anticipate users' needs, and adjust behaviours to maximise effectiveness and safety.

The evolution of robotics demonstrates a shift from mechanistic machines to intelligent, context-aware agents capable of autonomous reasoning and adaptive behaviour. Research into swarm robotics, multi-agent coordination, and human-robot interaction frameworks opens new opportunities for large-scale, distributed intelligence. As robots become increasingly capable of perceiving, learning, and reasoning in real-world settings, their integration into industry, healthcare, and daily life promises to accelerate innovation, efficiency, and societal benefits.

Healthcare: AI, IoT, and Personalized Solutions

Healthcare represents one of the most socially impactful application domains. AI-driven diagnostic systems, wearable and implantable sensors, and IoT-enabled platforms are revolutionising patient monitoring, early disease detection, and personalised interventions. Continuous, real-time monitoring of physiological parameters—from cardiac function to metabolic indicators—enables proactive healthcare strategies, timely interventions, and improved patient outcomes. These capabilities also reduce hospitalisation rates and enhance overall system efficiency.

Wearable and implantable devices are designed for biocompatibility, low power consumption, and user comfort, ensuring seamless integration into daily life. When linked with cloud-based analytics and AI decision support systems, these devices allow clinicians to detect anomalies early, optimise treatment plans, and monitor patient progress. Multi-device, IoT-enabled ecosystems support large-scale health monitoring, epidemiological studies, and integration of environmental factors, expanding access to high-quality care. These systems facilitate telemedicine, continuous feedback loops, and remote healthcare delivery.

Explainable AI ensures predictive models are transparent and trustworthy, addressing ethical and regulatory concerns. Clinicians can understand and validate AI recommendations, building confidence in adoption, particularly in critical care scenarios. By combining AI, IoT, and personalised medicine, healthcare solutions are becoming adaptive and continuously learning, paving the way for precision health tailored to individual needs.

Data Analytics, Wireless Communication, and System Optimization

Data-driven insights are essential for modern engineering; they support predictive analytics, intelligent decision-making, and system optimisation. Advanced signal processing, machine learning-based channel modelling, and adaptive resource allocation improve wireless communication systems, enhancing throughput, reliability, and energy efficiency. Networks can dynamically respond to user demands, environmental changes, and spectrum variations, maintaining consistent performance in complex scenarios.

Techniques such as transformer-based models, non-orthogonal multiple access, and adaptive interference cancellation illustrate the sophistication of modern communication network optimisation. Integrating multimodal data—from behavioural patterns to temporal and network interactions—enables robust anomaly detection, fraud prevention, and context-aware decision-making. Applications range from IoT-enabled smart cities to autonomous vehicle networks, where secure and reliable communication is critical for safety and efficiency.

Advances in data analytics and communications underpin intelligent systems, IoT networks, and smart grids, ensuring information flows efficiently, securely, and adaptively. Data-driven design also enhances resilience, fault tolerance, and energy efficiency, aligning innovation with sustainability goals. As systems grow in scale and complexity, the integration of analytics, communication, and adaptive control remains a cornerstone of next-generation engineering solutions.

Emerging Innovations and Interdisciplinary Synergies

This issue highlights the convergence of previously distinct technologies into unified, intelligent ecosystems. Holistic, interdisciplinary approaches increasingly allow AI, IoT, robotics, smart grids, and healthcare systems to interoperate seamlessly. Integrated systems leverage real-time data, adaptive algorithms, and autonomous control to achieve efficiency, resilience, and adaptability that were previously unattainable. Cross-domain collaboration produces solutions that simultaneously address industrial, environmental, and social challenges.

Cyber-physical systems (CPS) exemplify this synergy, bridging computation, communication, and physical processes. Hybrid cloud-fog architectures enable scalable, low-latency processing, while AI-driven control strategies support autonomous adaptation to environmental and operational changes. CPS are designed not merely to function but to learn, optimise, and anticipate, embodying fully intelligent infrastructures. Advanced sensing, predictive analytics, and secure communication ensure reliability in dynamic and resource-constrained settings.

Human-centred and ethical designs are equally critical. As intelligent systems enter everyday life, safety, interpretability, accessibility, and social impact guide engineering practice. By embedding principles of transparency, fairness, and sustainability, researchers are fostering technologies that are not only powerful but also trustworthy, equitable, and socially beneficial.

Challenges and Opportunities

Despite notable advancements, challenges persist. AI/ML systems must reconcile predictive power with interpretability, IoT networks must guarantee security and scalability, smart grids must uphold efficiency amid uncertainty, and robotics must secure robust autonomy in intricate, unstructured environments. The convergence of these technologies introduces further complexities related to interoperability, real-time adaptation, and resource management, highlighting the necessity for cross-disciplinary solutions.

Future directions include edge and federated learning frameworks aimed at enhancing privacy and minimising latency, low-power IoT devices designed for sustainable operations, and standard CPS architectures to promote modularity, scalability, and interoperability. Ethical, responsible, and sustainable engineering practices will underpin these innovations, ensuring that intelligent systems are not only technically proficient but also socially aligned and environmentally considerate. These prospects indicate a future where engineering advancements yield both high performance and societal benefit.

Conclusion

Volume 16, Number 2, of IJECE presents an insightful overview of the current landscape in electrical and computer engineering, emphasising the convergence of AI/ML, IoT, smart grids, robotics, healthcare, and emerging technologies. The research included in this issue highlights the transformative potential of interdisciplinary approaches, where data-driven intelligence, autonomous systems, and real-time monitoring work together to tackle complex engineering challenges. Within these domains, the integration of predictive analytics, adaptive control, and human-centred design indicates that intelligent systems can function efficiently, safely, and responsibly in dynamic and uncertain environments. As the field advances, these innovations are set to redefine the limits of what is achievable, fostering increasingly intelligent systems, resilient, and sustainable. The impact of these technologies reaches far beyond mere technical performance, influencing societal and ecological dimensions, from enhancing industrial productivity and optimising energy networks to improving healthcare delivery and promoting environmental stewardship. A focus on interpretability, ethical design, and adaptability ensures that advancements are not only technologically sophisticated but also socially responsible, trustworthy, and accessible. This issue functions both as a reflection of current achievements and as a guide for future exploration. By promoting interdisciplinary collaboration, advancing autonomous and adaptive solutions, and embedding the principles of sustainability and human-centered innovation, the research presented here lays the groundwork for the next generation of electrical and computer engineering. It underscores the opportunities, challenges, and synergies that will continue to shape intelligent systems, guaranteeing that technological progress translates into meaningful benefits for society, industry, and the environment.