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The Role of Internet of Things (IoT) in Enhancing Data Collection and Process Control in Applied Science

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Abstract: The Internet of Things (IoT) has emerged as a key technological framework in applied sciences, supporting advanced data acquisition, real-time monitoring, and autonomous process control. By connecting sensors, devices, and analytical platforms, IoT creates adaptive systems that improve accuracy, efficiency, and responsiveness in scientific and industrial environments. This review explores the expanding role of IoT in data collection and process optimisation, examining architectures, sensor mechanisms, communication protocols, and cloud or edge-based analytics. Applications across agriculture, healthcare, environmental monitoring, energy management, and industrial automation reveal how IoT enables predictive maintenance, resource optimisation, and intelligent control. The paper also addresses major challenges such as security risks, interoperability issues, scalability constraints, and power limitations. It concludes that IoT will continue to transform applied sciences as developments in edge computing, machine learning, and wireless networks foster more autonomous, resilient, and context-aware systems.

Keywords: Internet of Things, Data collection, Process control, Applied sciences, Intelligent monitoring

1. Introduction

The Internet of Things has redefined data gathering and process management by enabling seamless interaction between physical systems and digital networks. Through embedded sensors and communication technologies, IoT allows continuous monitoring and automated decision-making, aligning closely with the data-driven demands of modern applied sciences. Traditional data collection methods manual sampling, periodic measurements, and isolated monitoring systems are increasingly replaced by real-time, interconnected platforms capable of capturing complex variables with high precision. As sensor technology becomes more affordable and wireless communication more robust, IoT has become essential across disciplines ranging from environmental analysis to advanced manufacturing [1]. This review examines how IoT enhances data collection and process control, the challenges involved, and future directions.

2. IoT and Data Collection in Applied Sciences

IoT advances data collection by utilising distributed sensor networks that gather environmental, biological, and mechanical parameters at multiple scales. These networks, supported by cloud computing and edge analytics, enable real-time processing and seamless storage of large datasets [2]. Environmental sciences benefit through automated air-quality stations, water-quality sensors, and climate-monitoring nodes that transmit continuous data for predictive modelling. In agriculture, IoT systems including soil moisture sensors, weather monitors, and remote irrigation units enable precision farming, reducing resource wastage and improving crop yields [3]. Wearable devices and remote health sensors generate physiological data crucial for personalised healthcare and early diagnosis. Across disciplines, IoT facilitates higher granularity, lower latency, and more reliable scientific observations.

3. IoT in Process Control and Automation

IoT significantly strengthens process control by creating adaptive systems capable of autonomous decision-making. Smart manufacturing facilities integrate IoT sensors to monitor equipment performance, predict failures, and optimise workflows. This aligns with Industry 4.0 frameworks where IoT is central to cyber-physical systems [4]. Energy management relies on smart meters, grid sensors, and distributed controllers to maintainload balance and reduce consumption. In chemical and environmental engineering, IoT systems track parameters such as pH, temperature, pressure, and flow rate, enabling real-time corrective action and reducing human intervention. Edge computing reduces dependence on central servers, allowing local processing and faster system response. Together, these capabilities enable robust, self-regulating process-control environments.[Fig. 1]

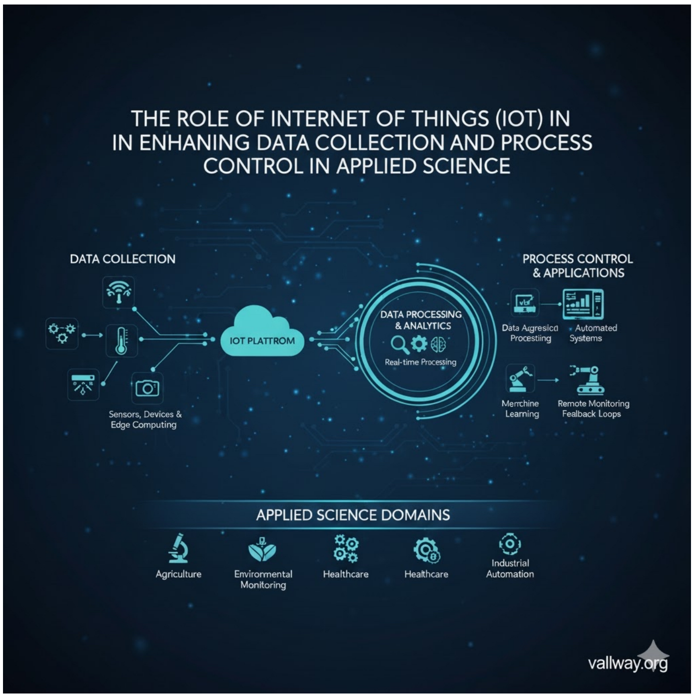

Fig. 1 internet of things.

4. Challenges and Limitations

Despite its advantages, IoT deployment presents several challenges. Security vulnerabilities pose the most significant threat, as interconnected devices increase exposure to cyberattacks, data breaches, and unauthorised manipulation [5]. Interoperability issues arise due to heterogeneous devices, closed communication standards, and vendor-specific architectures. Many IoT systems also struggle with scalability, as increased sensor density demands greater bandwidth and computational power. Power limitations affect remote IoT nodes, particularly those deployed in isolated or inaccessible areas. Furthermore, managing large volumes of streaming data requires advanced storage, compression, and analytic frameworks. Addressing these issues requires coordinated progress in standardisation, encryption technologies, and energy-efficient system design.

5. Conclusion

IoT has become a transformative component of applied sciences, revolutionising data acquisition and process control across diverse scientific and industrial domains. Its ability tosupport real-time monitoring, enhance system intelligence, and enable predictive decision-making strengthens performance and operational reliability. While challenges related to security, interoperability, and scalability persist, emerging technologies such as 5G connectivity, machine learning, and edge computing will continue to expand IoT's impact. The future of applied sciences increasingly depends on IoT-enabled systems that are adaptive, resilient, and capable of integrating complex data streams to optimise processes and support scientific advancement.

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