A COMPREHENSIVE REVIEW OF RECENT ADVANCES IN IOT, AI AND SMART SYSTEMS FOR SECURITY, HEALTHCARE, AUTOMATION, AND SMART ENVIRONMENTS

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**ABSTRACT**

The Internet of Things (IoT), artificial intelligence (AI), and sensing technologies are transforming a wide range of industries, from environmental monitoring and healthcare to industrial automation and smart energy. This review paper presents a comprehensive overview of 33 recent research studies covering the reliability of IoT systems, wearable healthcare technologies, security frameworks, real-time monitoring using drones, smart waste management, photovoltaic tracking systems, blockchain-enabled IoT, sensorless detection techniques, autonomous robotic systems, and innovative material sensing approaches. Each study's methodology, key innovations, applications, and performance assessments are discussed. By analyzing these advances, this paper identifies emerging trends, integration challenges, and future research directions essential for next-generation smart systems development.

**Keywords:** IoT , Artificial Intelligence, Smart Systems, Deep Learning, Wireless Sensing, UAVs, Block chain, Reliability, Automation, Healthcare Technology, Smart Homes, Renewable Energy, Structural Health Monitoring.

1. **INTRODUCTION**

In recent years , the synergistic integration of IoT, AI, and sensing platforms has accelerated technological advancements across industries. Smart systems are now capable of real-time monitoring, predictive maintenance, autonomous decision-making, and environmental interaction, reshaping the way humans interact with technology. This review aims to consolidate developments across 33 research studies spanning diverse fields, offering a detailed understanding of how emerging technologies are being utilized for fire detection, wearable healthcare, environmental protection, smart infrastructure, energy optimization, and more. Each section categorizes the papers thematically, offering insights into methodologies, system designs, and application results.

1. **MAIN BODY**

**2.1 Reliability, Security, and Accountability in IoT Systems**

Reliability of IoT Systems for Fire Detection focused on improving detection accuracy while minimizing false alarms through sensor network optimization. Advanced Security Frameworks for UAV and IoT employed deep learning to prevent cyber-attacks on unmanned systems. IOT-Friendly Certificateless Signcryption Schemes introduced efficient encryption techniques for secure communication without heavy computational overhead. Empowering Autonomous IoT Devices in Blockchain addressed energy-efficient blockchain integration through gasless transaction mechanisms. Designing Accountable IoT Systems proposed data integrity models to overcome storage and audit challenges in large-scale IoT deployments An eSIM-Based Remote Credential Provisioning for IoT Devices presented a secure authentication protocol suited for 5G-enabled IoT systems. Authorization Models for IoT Environments: A Survey explored existing models to enhance privacy and access control.

**2.2 Smart Healthcare and Wearable Monitoring Systems**

Wearable Healthcare and Continuous Vital Sign Monitoring discussed IoT-enabled wearables that allow real-time patient monitoring. Brainwave and Head Motion Control of Smart Home Systems applied brain-computer interfaces (BCI) for assisting disabled individuals. Effect of PWM LED Light on Dental Composites (two studies) explored how LED modulation affected temperature rise and polymerization quality in dental materials.

**2.3 Smart Environmental and Infrastructure Monitoring**

AI-Powered IoT and UAV Systems for Illegal Logging Prevention combined drone surveillance with deep learning for forest protection. Design of Automatic Flood Control System in Yogyakarta demonstrated an IoT-based real-time flood response model.Smart Trash Bin Using Markov Model utilized stochastic modeling for reliability assessment and waste management optimization. IoT-Based Phosphate Detection Using Graphite/PDMS Sensors introduced low-cost chemical detection methods for water quality monitoring. Autonomous Tracking of Chemical Plumes Using Petri Nets proposed a robotics-based approach for hazardous gas leak detection. Animal Detection System for Motor Vehicle Drivers designed a real-time driver assistance tool using object recognition techniques.

**2.4 Innovations in Renewable Energy and Smart Grids**

Solar Panel Power Investigation Using Tracking Systems compared fixed, single-axis, and dual-axis systems to maximize solar harvesting. Remote Islanding Detection in Wind-Solar Hybrid Plants presented a reliable method to identify microgrid disconnections using smart analysis.

**2.5 Sensing and Structural Health Monitoring**

Sensorless Zero-Crossing Detection for AC Signals offered a microcontroller-based approach without external sensors. Instrumented Drop-Bar Impact Testing of Structural Steels provided insights into fracture behaviors through mechanical testing setups. Modal Analysis of Underwater Hull Cleaning Robots investigated the environmental effects on marine robot stability. Experimental and Numerical Analysis of Free Vibration of Delaminated Curved Panels focused on structural failure prediction techniques Self-Powered 2D Barcode Recognition System Using Triboelectric Nanogenerators demonstrated energy harvesting combined with identity verification.

**2.6 Advanced Sensing and Material Innovations**

Sensitive Oxygen Detection Using Diffused Integrating Cavity presented enhanced gas absorption technologies. Influence of Ultrasonic Waves on Gas-Solid Flow in CFB Risers improved solid particle dispersion efficiency in industrial settings. Development of an Electric Nose System (E-Nose) for Edible Seeds created non-destructive aromabased shelf-life estimation technologies. Second Generation Laser-Heated Microfurnace for Graphite Samples enabled high-precision sample preparation for analytical testing Automation and Interlock System for Liquid-Metal Purification Facilities focused on safety in experimental nuclear fusion setups. Low-Cost Linear Force Feedback Gripper Control developed economical robotic grasping mechanisms.

**2.7 Intelligent Mechatronics and Control Systems**

FPGA-PLC-Based Multi-Channel Position Measurement introduced high-speed, accurate motion sensing for industrial automation. Nickel Alloy Coated Fuel Tank with Digital Fuel Level Indicator Security System improved reliability and theft-prevention for fuel storage systems.

1. **RESULTS AND DISCUSSION**

The reviewed studies exhibit remarkable integration of AI and IoT in various domains. For instance, fire detection systems demonstrated high fault-tolerance through sensor fusion, while blockchainenhanced IoT devices tackled energy constraints. Security-focused research revealed the growing need for lightweight cryptographic protocols and eSIM-based authentication. A critical analysis shows that while performance and innovation are accelerating, issues like data privacy, real-time decision making, and hardware limitations persist.

1. **CONCLUSION**

The reviewed research highlights how IoT, AI, and advanced sensing technologies are converging to enable smarter, safer, and more efficient systems across domains. Reliability, security, and energy efficiency emerge as critical design factors, particularly for real-time and autonomous operations. From healthcare to environmental sustainability, the innovative methodologies presented offer promising pathways for future research and commercialization. Continued interdisciplinary collaboration and focus on scalability, security, and resilience will be essential to advance nextgeneration IoT and smart systems

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