

ABSTRACT:

Nanomaterials-Based Sensing Platforms for Enhanced Situational Awareness Using Augmented Artificial Intelligence

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The rapid convergence of nanotechnology, artificial intelligence (AI), and advanced materials science is revolutionizing sensing technologies, enabling platforms with unprecedented precision, adaptability, and intelligence. Once confined to narrow functions, traditional sensors are being reimagined as multifunctional, autonomous systems capable of thriving across diverse domains—from biomedical diagnostics and environmental monitoring to aerospace and defense. Quantum sensors, leveraging entanglement and coherence, achieve ultra-sensitive measurements of time, gravity, and magnetic fields, pushing far beyond classical limits. Bio-inspired and bio-integrated sensors, meanwhile, harness living systems or synthetic analogues for real-time, non-invasive physiological monitoring, enabling breakthroughs in personalized healthcare and human-machine symbiosis. The infusion of AI and edge computing equips sensors with on-device intelligence, empowering context-aware decision-making, predictive analytics, and self-calibration in dynamic environments. Advances in flexible, stretchable, and self-healing materials further enhance adaptability to unconventional surfaces and extreme conditions, while energy-harvesting solutions address power constraints by enabling self-sustained operation. Together, these innovations redefine sensing as an active, networked capability rather than a passive data-collection tool, fostering the emergence of “cognitive sensing ecosystems” that autonomously learn, adapt, and evolve. The presentation outlines these futuristic sensors that will shape security posture, resilient societies, sustainable industries, and secure infrastructures, while simultaneously raising pressing questions of ethics, privacy, and governance. Although the full potential may await the advent of artificial general intelligence (AGI), which would quite literally sense the unseen future, these technologies herald a new era of intelligence-driven interaction among humans, machines, and the environment.