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minimal latency, and high fidelity, remains a critical bottleneck. Overcoming these hurdles requires innovations in AI model robustness, noise-aware signal processing, and context-adaptive learning algorithms that can function reliably in the presence of physical constraints inherent to nanoscale sensing.[65] Physical nanosensors, notably nano-electromechanical systems, are adept at measuring stress, pressure, or temperature with unprecedented precision.[66] However, their inherent mechanical fragility and vulnerability to environmental noise present major challenges for reliable field deployment, especially in dynamic outdoor environments or *in vivo* biomedical applications where structural stability and signal fidelity are critical.[67] The miniaturization to the nanoscale does not inherently guarantee superiority. Instead, it necessitates precise material control, robust calibration protocols, and advanced signal processing frameworks to ensure accuracy and utility across varied deployment scenarios.[68]

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While the previous section discussed the functional classifications, performance advantages, and limitations of nanosensors across various applications, their effective integration into real-world systems demands more than advanced sensing capabilities. One of the key challenges lies in ensuring reliable and efficient data transmission from the nanoscale domain to macroscopic ICT systems. The following subsection explores Communication Technologies that address this challenge by

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