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Triboelectric Edge Computing Sensors and their Application in the IS Supply Chain

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Abstract

Edge computing, a distributed computing paradigm, enhances response times and conserves bandwidth by conducting computation and data storage near the source. Using sensors to gather real-time data, edge computing devices process information locally before transmitting it to a centralized cloud system for additional analysis. Triboelectric sensors excel in edge computing due to their affordability, minimal power consumption, high accuracy, and effortless integration.

Kirigami Triboelectric Edge Computing Sensors (K-TECS) employ the triboelectric effect to detect changes in physical properties such as pressure and force. Drawing inspiration from the Japanese Kirigami art form, these sensors utilize thin sheets of plastic or metal featuring intricate cut patterns to increase flexibility. K-TECS provide customization, precision, and energy efficiency compared to traditional sensors since they don't require external power sources. Their adaptability and accuracy make them suitable for various industries, including medical devices, robotics, and consumer electronics like touchscreens and virtual reality headsets, where precision and efficiency are vital.

K-TECS's flexibility allows edge computing sensor networks to extend into diverse aspects of life, including human condition monitoring. A K-TECS edge computing architecture comprises an IoT sensor layer, an edge computing layer, and a cloud layer. K-TECS and signal processing circuitry constitute the IoT sensor layer, while Bluetooth connections to a mobile cloudlet link the IoT layer to the edge computing layer. Local computation within the edge layer bolsters security and reduces latency before data reaches the cloud layer, where machine learning algorithms facilitate decision-making.

Architectures can be single-cluster, featuring a one-to-one relationship between K-TECS and a mobile cloudlet, or multi-cluster, where cluster heads consolidate data from various K-TECS for examination. Decentralized Resource Auctioning (DRA) allocates processing power and minimizes latency by employing an "auctioneer" and multiple "bidders" (clusters) transmitting data to the mobile cloudlet, with task prioritization based on processing resource consumption.

Single-cluster architecture applications include medical monitoring, in which sensors are applied to different body areas, transmitting data to a Bluetooth-enabled device for early health issue detection and post-discharge patient monitoring. In structural monitoring, K-TECS clusters can be used in construction projects to track strain, movement, and environmental conditions, ensuring worker safety and analyzing building conditions for research purposes.

Multi-cluster architecture allows doctors to monitor various patients' conditions through a single IoT dashboard, using multiple sensor clusters for improved data resolution. In structural monitoring, this method offers higher resolution and wider coverage, enabling detailed condition modeling and consolidated data analysis. This architecture can also optimize agricultural processes, detecting and addressing issues with individual plants and preventing problems like fires or floods from spreading throughout the crops.

The combination of triboelectric edge computing sensors, machine learning, and the information supply chain enables businesses to gain unparalleled insights into their operations. TECS collect real-time data, facilitating swift problem identification and corrective action before issues worsen. Machine learning algorithms use this data to forecast future events or outcomes, promoting proactive measures. The information supply chain ensures prompt data delivery for immediate action. These essential components of digital transformation help businesses maintain competitiveness while boosting efficiency and profitability across their organizations.