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Perspective

The advancement of microsensors in the age of IoT and Industry 4.0

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Sensors are devices that receive input and produce an analog or digital output signal. They are found in almost every aspect of human activity, from robotics, medical devices, consumer electronics, automobiles, to residential appliances and industrial automation [1]. In recent years, the rapid increase of interconnected devices that are connected to the internet has defined a new technological term: the "Internet of Things" (IoT). IoT has created a demand for acquiring, collecting, and processing vast amounts of data, thus shaping the upcoming new industrial revolution "Industry 4.0" [2].

Consequently, a new area of need has emerged: the development of machine-to-machine communication (M2M) middleware applications and the expansion of their envisioned use [3]. In this context, sensory device requirements have changed from transforming a signal and passing the information to a micro-computer, a database, or a controller, to processing the raw data on the device (edge) and communicating their result (sensor fusion) to another device [3]. This data mining process has often involved implementing big data and AI data processing and mining techniques or extending the capabilities of current systems infrastructure. Moreover, recent literature has provided many new designs of highly sensitive and efficient microsensors in the fields of microfabrication, surface modification, and signal processing [4,5].

To further develop this inter-connected system that uses smart devices, scientists have needed to enhance the capabilities of current sensor technologies [6]. As such, the term "microsensor", which was first introduced in the 1980s, has resurfaced and aims to describe low-cost and low-power small-size devices that are either applied on current devices or via intergraded circuits. Microsensors have different forms depending on what they aim to measure and vary in their physical quantities. Some of the physical quantities that are frequently encountered and require measurement are speed, position, temperature, force, fluid flow, level, pressure, and acceleration.

Therefore, microsensors can be categorized based on the input signal as [7,8]:

- Thermal sensors (e.g., temperature)
- Mechanical sensors (e.g., pressure, torque)
- Chemical sensors (e.g., pH, gas)
- Biosensors (e.g., proteins, DNA)
- Optical sensors (e.g., light sensors)
- Radiant microsensors (e.g., UV/infrared light, radiation)

Additionally, depending on their properties, there are 3 types of microsensors [8–10]:

- Biochips: perform multiple biochemical reactions simultaneously on a single chip [10].

- Nanosensors: detect and respond to physical or chemical stimuli in the nanoscale range [11].
- Micro-electro-mechanical systems: perform actuated decisions and control mechanical systems on a microscale level [12].

The types of microsensors based on their input signals and their properties are presented in **Figures 1** and **2** respectively.

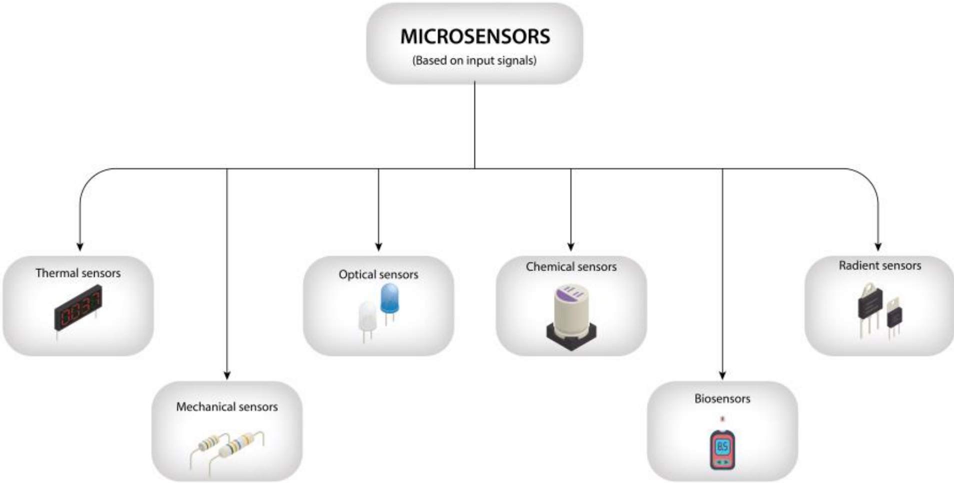

Figure 1. Types of microsensors based on the input signal.

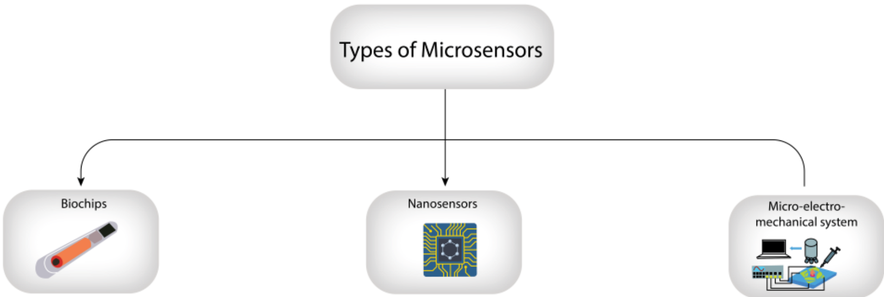

Figure 2. Types of microsensors based on their properties.

A better understanding of physical phenomena and the development of new materials have resulted in the construction of sensors with high accuracy, fast response, and a wide measurement range. Specifically, the future of microsensors does not lie in following Moore's law i.e., decreasing their size and augmenting their hardware capabilities but rather in focusing on ubiquitous and edge computing. This means that scientists focus on treating each sensor node as a unique and autonomous entity that would perform a specific task whether that be communication or data acquisition and mining. As for future works, several complex monolithic architectures exist that need to be segmented into small autonomous microsensors that will be independently used in a variety of applications to provide systems a boost in performance and fault tolerance.

Microsensors are expected to revolutionize and influence almost every aspect of human activity. Our journal aims to highlight the importance of microsensors and their rapid advancement in the areas of engineering, microelectronics, and emerging sensor technologies.

Conflict of interest: The author declares no conflict of interest.

References

1. Wan T, Shao B, Ma S, et al. In-sensor computing: Materials, devices, and integration technologies. Advanced Materials 2022; 2203830. doi: 10.1002/adma.202203830
2. Gazis A. What is IoT? The Internet of Things explained. Academia Letters 2021; 1003. doi: 10.20935/AL1003
3. Hasan MH, Al-Ramini A, Abdel-Rahman E, et al. Colocalized sensing and intelligent computing in micro-sensors. Sensors 2020; 20(21): 6346. doi: 10.3390/s20216346
4. Sudha M, Viveka S. A comprehensive review of architecture, classification, challenges, and future of the internet of medical things (IoMTs). Medical Journal of Babylon 2022; 19(3): 311–317. doi: 10.4103/MJBL.MJBL-5-22
5. Dodevska T, Hadzhiev D, Shterev I. A review on electrochemical microsensors for ascorbic acid detection: Clinical, pharmaceutical, and food safety applications. Micromachines 2023; 14(1): 41. doi: 10.3390/mi14010041
6. Gazis A, Katsiri E. Smart home IoT sensors: Principles and applications—A review of low-cost and low-power solutions. International Journal on Engineering Technologies and Informatics 2021; 2(1): 19–23. doi: 10.51626/ijeti.2021.02.00007
7. Martins AB, Farinha JT, Cardoso AM. Calibration and certification of industrial sensors—A global review. WSEAS Transactions on Systems and Control 2020; 15: 394–416. doi: 10.37394/23203.2020.15.41
8. Microsensors market size, share, analysis report. Available online: https://www.marketresearchengine.com/microsensors-market (accessed on 28 July 2023).
9. Algamili AS, Khir MHM, Dennis JO, et al. A review of actuation and sensing mechanisms in MEMS-based sensor devices. Nanoscale Research Letters 2021; 16(1): 1–21. doi: 10.1186/s11671-021-03481-7
10. Huang QA. Micro Electro Mechanical Systems. Springer Singapore; 2018.
11. Hang X, He S, Dong Z, et al. Nanosensors for single-cell mechanical interrogation. Biosensors and Bioelectronics 2021; 179: 113086. doi: 10.1016/j.bios.2021.113086
12. Jena S, Gupta A. Review on pressure sensors: A perspective from mechanical to micro-electro-mechanical systems. Sensor Review 2021; 41(3): 320–329. doi: 10.1108/SR-03-2021-0106