Guest Editorial: Special Section on Conformable Decoders

Conformable decoding is the harbinger of the era of personalized medicine. Current medical care and monitoring often require extensive, costly instrumentation that is difficult to use, thereby reducing patient compliance, promoting overfitting of temporally fragmented data sets, and limiting the scope of medical exploration. Unintrusive, comfortable, self-powered devices that can be worn for a few weeks will allow researchers to bring their studies out of the lab environment and into people's homes with continuous monitoring capabilities. Soft, stretchable, and imperceptible electronics are essential to intimately integrate with human skin and listen to what our body is really telling us. Despite enormous progress in this field, substantial technical challenges remain when transitioning from rigid to soft systems. In addition, visualizing data relevant to clinical conditions is also challenging. This special section presents three research studies to highlight recent advances in this research area.

Zavanelli et al. provide a comprehensive review of advances in printed strain sensors for motion recognition, emphasizing their potential for applications including sports monitoring, healthcare, and human-machine interfaces. The review explores key advances in materials such as conductive polymers, nanowires, and nanoparticles, which enable high sensitivity, durability, and flexibility [A1]. These sensors use innovative fabrication techniques, including inkjet and aerosol jet printing, to achieve scalable and cost-effective production while maintaining performance levels. The authors highlight the role of machine learning algorithms in processing sensor data and enhancing motion recognition accuracy for adaptive solutions. Additionally, they discuss the integration of these sensors into stretchable substrates to allow for seamless compatibility with human skin, along with the importance of biocompatibility and mechanical robustness for long-term use. This review highlights the transformative potential of these technologies while addressing key challenges in scalability, manufacturing efficiency, and application-specific sensor design.

Advancing the integration of materials with complex biological surfaces, Yamada et al. introduce their Two-Dimensional Array Sinusoidal (TDAS) conductor as a solution for continuous monitoring of complex biological surfaces with high conductivity and flexibility [A2]. By using microfabrication techniques to create sinusoidal wave structures on polydimethylsiloxane (PDMS) substrates with a sputtered gold layer, the researchers achieved uniform crack distribution and resistance to mechanical stress. The authors demonstrated its applicability for curved and moving surfaces by developing a photoelectric pulse wave sensor capable of detecting fingertip pulse waves with a high signal-to-noise ratio. This capability exemplifies the potential of TDAS conductors to facilitate non-invasive, stress-free monitoring of dynamic biological systems. Its scalability and simple fabrication process further position it as a key innovation in personalized medicine, enabling advanced mapping systems for parameters like oxygen saturation and pulse waves.

To enhance wearable bioelectronic devices in health monitoring, Chansaengsri et al. introduce a novel conductive carbon-based ink for screen-printing onto fabric substrates. The ink combines graphite composites with polymer emulsion and calcium carbonate additives, achieving high conductivity, mechanical durability, and flexibility [A3]. The ink enables the fabrication of electrodes that deliver high signal clarity in electrocardiogram (ECG) monitoring and demonstrate strong correlation in non-invasive blood pressure (NIBP) measurements for systolic and diastolic values. Additionally, the ECG signals were integrated into machine learning models, with the Random Forest algorithm achieving an optimized F1 score for predictive performance of 99.9%. These results demonstrate the durability and efficacy of carbon-based screen-printing inks in creating biocompatible and non-invasive health monitoring systems that may be a cost-effective and scalable alternative to conventional Ag/AgCl electrodes.

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Appendix
Related Works

[A1] N. Zavanelli, K. Kwon, and W.-H. Yeo, "Printed strain sensors for motion recognition: A review of materials, fabrication methods, and machine learning algorithms," *IEEE Open J. Eng. Med. Biol.*, vol. 6, pp. 353–381, 2024, doi: 10.1109/OJEMB.2023.3330290.

[A2] H. Yamada, R. Kawai, R. Niwa, and K. Tsukada, "Two-dimensional array sinusoidal waves conductor for biometric measurements," *IEEE Open J. Eng. Med. Biol.*, vol. 6, pp. 382–389, 2024, doi: 10.1109/OJEMB.2024.3374975.

[A3] K. Chansaengsri, B. Tunhoo, K. Onlaor, and T. Thiwawong, "Developing a vital signal detection electrode for fabric substrate using a high-performance conductive carbon-based ink," *IEEE Open J. Eng. Med. Biol.*, vol. 6, pp. 390–399, 2024, doi: 10.1109/OJEMB.2024.3431030.

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