Stretchable Auxetic textile-based Strain Sensor

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Abstract: In this study, we have design, fabrication, and characterization of an ultra-stable and stretchable auxetic textile-based strain sensor for applications in human motion analysis and deep learning-assisted soft robotic detection. The developed strain sensor is based on a novel auxetic textile structure that has negative Poisson's ratio (NPR), and allows excellent stretchability and resilience without permanent deformation, increased free mobility, and extensive usage without affecting the sensor's sensing capabilities. The experimental result shows that the auxetic strain sensor has an excellent NPR value of (-0.25), high sensitivity of 11.2, outstanding linearity of 99.81%, ultralow detection limit of 0.5%, long-term durability, consistent repeatability, and stability over a wide range of tensile strains.

Keywords: *auxetic properties, strain sensors, mechanical properties, robotic detection.*

To develop an auxetic strain sensor, here are the subsequent procedures: Initially, the process involves creating auxetic fabric [1], which is then coated with conductive materials derived from GNP-CNT and applied directly onto the surface of the fabric.

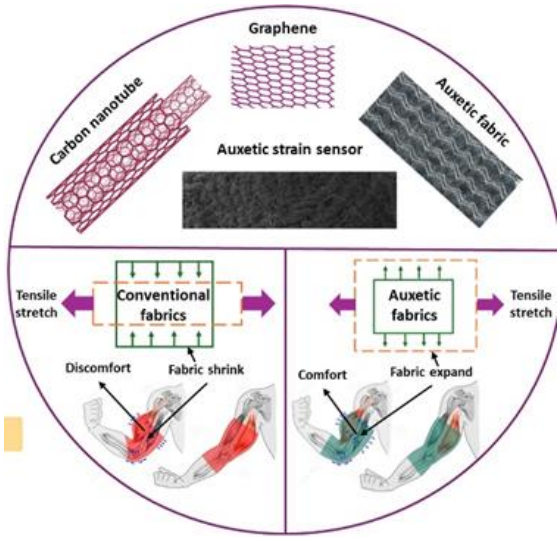

Figure 1. Auxetic textile-based strain sensor

Auxetic strain sensor was fabricated by immersing the auxetic fabric in graphene (GNP) and carbon nanotube (CNT) solutions. The GNP-CNT, a highly regarded nanomaterial, has attracted significant attention in the field of flexible strain sensing due to its exceptional mechanical, electrical, and sensing attributes [2]. Auxetic strain sensors that employ GNP-CNT typically function based on the principle of piezoresistance [3]. This principle refers to the change in electrical resistance of a material in response to applied mechanical strain. Auxetic fabrics can serve as active strain sensors, a critical component for wearable sensing electronics [4]. The relative resistance changes (RCR) increase linearly with the progressive application of tensile strain across a wide range of 100% for the auxetic fabric-based sensor. The Gauge Factor (GF) is approximately 11.2, and the linearity is 99.81% within a broad strain range from 0 to 100%, while the sensors exhibit a similar GF value under a smaller strain range from 0 to 20%. Notably, the strain sensor displays a continuous electrical resistive signal at different strain levels of 0.5%, 1%, 1.5%, and 2.5%, confirming satisfactory sensing properties and reproducibility. The developed auxetic strain sensor offers exceptional sensitivity, durability, and adaptability to complex deformations, making it an optimal choice for various applications in the fields of wearable electronics, healthcare, sports, robotics, and human-computer interactions.

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