SIMON FRASER UNIVERSITY

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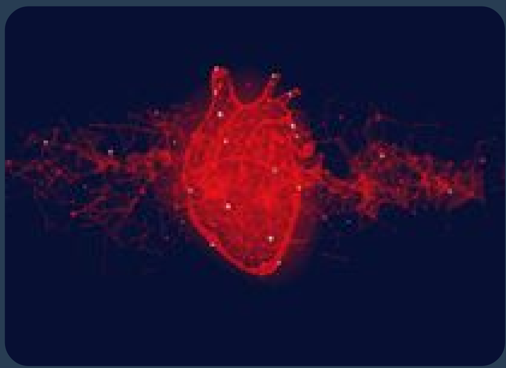
3D Printed Leech-mimic Origami (LMO) Blood Pressure Sensor

3D printed origami dry electrode for BP monitoring sensing robot applications, which provides a sustainable solution to monitor heart health



Request an introduction

Reference: 2021-004

Header image is purely illustrative. Source: dima_oris, stock.adobe.com.uk/323426606, stock.adobe.com

IP Status

Patent application submitted

Background

Monitoring of blood pressure (BP) plays a crucial role in medical diagnosis because high BP is deeply related to several chronic diseases. The increasing prevalence of cardiovascular diseases and the growing of aging population are leading the rising demand for personal healthcare systems that collect the BP of patients during their daily life.

Therefore, accurate and/or frequent BP monitoring without clinical settings (such as mobile or wearable devices for remote or general healthcare monitoring) is anticipated to drive the global ECG sensor market. In fact, both ECG and PPG (photoplethysmography) technologies are becoming easily available, low-cost, and convenient with portable devices. The pulse arrival time (PAT) parameter, indicating the time taken from the pulse waveforms to traverse from the heart to a distal site, is often used with the paired ECG-PPG sensing system monitoring the BP continuously. The BP monitoring with PAT requires reliable ECG signals near the heart and PPG signals on the distal site. Thus, stable positioning of dry ECG electrodes on the skin is essential to obtain effective ECG signals.

Tech Overview

SFU researchers have developed a leech-mimic 3D printed origami (LMO) sensor composed of the non-auxetic tip with auxetic bodies to demonstrate biosignal sensing fingertip.

The origami sensor is composed of the non-auxetic tip with auxetic bodies, inspired by a leech (Figure 1a). It is expected that the non-auxetic structure in the designed origami sensor is expanded, but the auxetic part is shrunk when the dry electrode is pressed to the patient's skin, which creates local vacuum as shown in Fig. 1b. During compression, the expansion of the non-auxetic part from the photo in Fig. 1c is observed, resulting in the increased area at x,y plane view. In contrast, the auxetic part is shrunk, reflecting inner space is reduced. Also, the origami design has an additional distinctive feature, rotating at applying z directional force. Their corresponding area changes are measured as a function of compressed height in Fig. 1d. The non-auxetic structure area shows linearly upward trends at a more compressed length, Δh, and at 8 mm of Δh, its area at x, y plane view is reached to be 1.6, larger than a de-compressed state. In the case of the auxetic origami part, the area is reduced to be about 0.4 compared to its pristine after compression. The rotating behavior of the origami design has been evaluated in Fig. 1e. The rotating angle at Δh also changes linearly, indicating axial shifting properties from z-directional force to rotating force as torque. Researchers expect that the origami structure forms the standby state to pump after the compression, and the structure starts to suck during de-compression like a leech. As shown in Fig. 1f, the leech-mimic structure (LMO) stably contacts and sucks the human finger so that the LMO is still attached to the fingertip when the finger is moved.

Parametric studies of LMO design to enhance ECG sensing abilities were performed. Also, the serpentine designs of ECG dry electrodes were employed, demonstrating advantages for the expansion and contraction of the conformal ECG sensor.

Figure 1

Further Details

Kim, TH., Bao, C., Chen, Z. et al. 3D printed leech-inspired origami dry electrodes for electrophysiology sensing robots. npj Flex Electron 6, 5 (2022). https://doi.org/10.1038/s41528-022-00139-x

Benefits

- Monitors heart health conveniently – fast turnaround time
- Cost-efficiency and production efficiency via 3D printing for manufacturing
- Sustainable solution – reusable sensors generating least amount of medical garbage
- Provides continuous ECG measurement for long period of time – not possible with wet gel electrodes
- Easily integrated with sensing robot systems, which bridge remote or general monitoring between medical personnel and out clinic patients – reliable ECG measurement through human-robot interaction, comparable with the commercial wet ECG electrodes

Applications

- Remote, ambulatory and continuous heart health monitoring in skin-sensitive patients like children/seniors

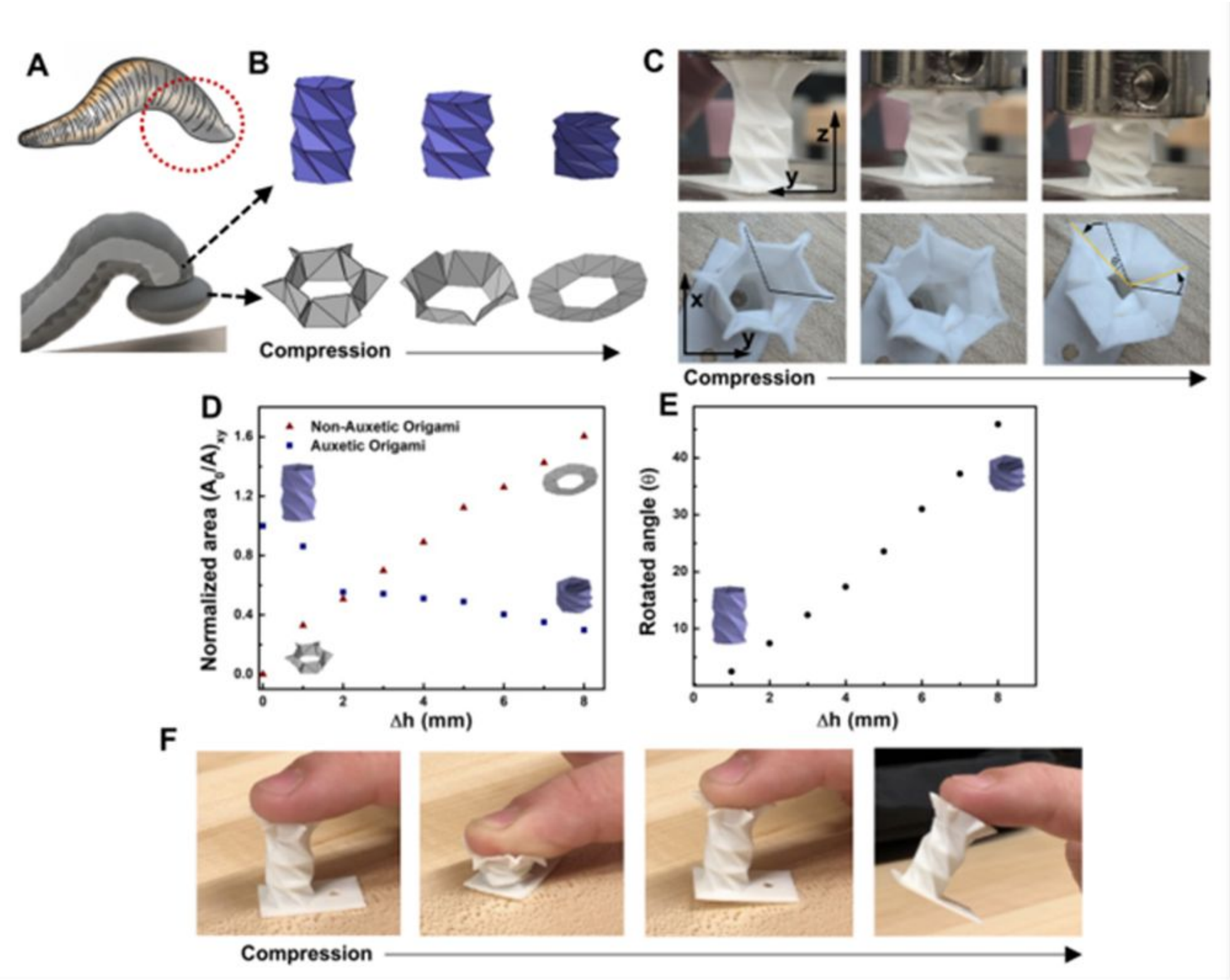
Patents

- Regular application filled, CA 3134287

Appendix 1

Figure 1

The mechanical behavior of designed LMO structure. (A) Schematics of the posterior sucker and body of leech and (B) Their corresponding leech-inspired 3D auxetic origamis with the folding features under compression. (C) The photos of 3D printed LMO at compression, side views (top), and top views (bottom). The graphs of (D) the normalized area changes and (E) rotated angles at different compressed distances. (F) Representative photos of the adhesive performance of the designed LMO.



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