Compliant 3D scaffold as self-training skeletons for bio-hybrid robots

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Biomimetic soft robotic systems aim to design advanced functional robotic platforms able to perform gentle actuation by resembling some of the mechanisms and designs of their biological counterparts [1]. Some of the desired unique from this living entities include self-healing, energy efficiency, power-to-weight ratio, adaptability, or bio-sensing capabilities [2]. Although most of the designs resemble the well-known structures in nature (i.e. medusoid that mimics a jelly-fish motion dynamic [3]), simpler structures have served to stablish key design rules for efficient bio-robotic platforms. Some examples are a cantilever structure where cardiac cells where immobilized [4] or a system based on two legs joined by a beam where a 3D skeletal-muscle cell construct is assembled [5].

In our case, we developed a skeleton-muscle based bio-robot with an integrated compliant skeleton whose design is based on a spring serpentine. Such configuration not only provided mechanical integrity to the bio-robot system, but also allowed an on-demand bending and a mechanical self-stimulation in absence of any external electrical input. Corresponding finite element analysis were done to both find the optimal geometrical stiffness to achieve the desired asymmetry/ buckling effect for efficient motion and the mechanical self-stimulation for an enhanced output force.

REFERENCES

[1] T. Patino, R. Mestre, S. Sánchez, Lab Chip. 16, 2016, 3626–3630.
[2] C. Appiah, C. Arndt, K. Siemsen, A. Heitmann, A. Staubitz, C. Selhuber-Unkel, Adv. Mater. 31, 2019, 1807747.
[3] J. C. Nawroth, H. Lee, A. W. Feinberg, C. M. Ripplinger, M. L. McCain, A. Grosberg, J. O. Dabiri, K. K. Parker, Nat. Biotechnol. 30, 2012, 792–7.
[4] J. Park, J. Ryu, S. K. Choi, E. Seo, J. M. Cha, S. Ryu, J. Kim, B. Kim, S. H. Lee, Anal. Chem. 77, 2005, 6571–6580.
[5] C. Cvetkovic, R. Raman, V. Chan, B. J. Williams, M. Tolish, P. Bajaj, M. S. Sakar, H. H. Asada, M. T. A. Saif, R. Bashir, Proc. Natl. Acad. Sci. U. S. A. 111, 2014, 10125–30.