A Neuromorphic Tactile Sensor based on Soft Optical Fiber

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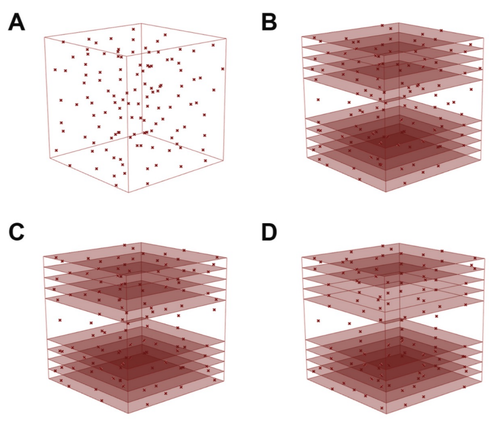
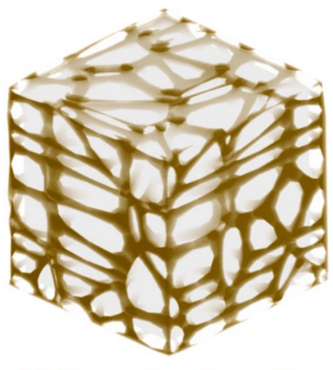
Problem Statement

- The robot needs a full history of force during the impact process, in order to code with the impact mitigation problem.
- This requires a novel type of sensor capable of enduring a distance of stroke longer than previous tactile sensor.
- Inspired by mammal nervous system, we propose a tactile sensor for impact robotics, with 3D-printed soft porous scaffold and soft optical fibers, analogous to mammal skin and mammal nerve.
- We use an encoder-decoder machine learning approach to recover the history of impact force from the optical fiber signal time series.

Workflow and Result

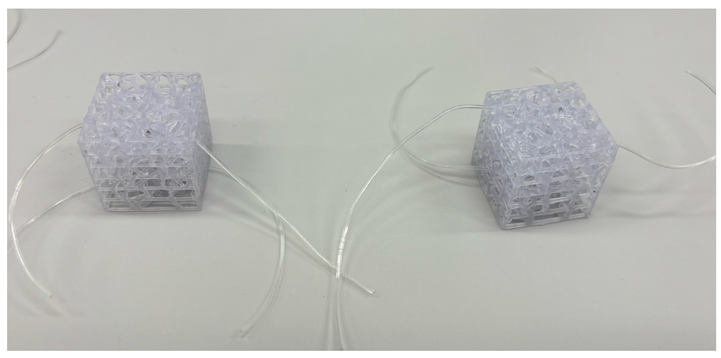


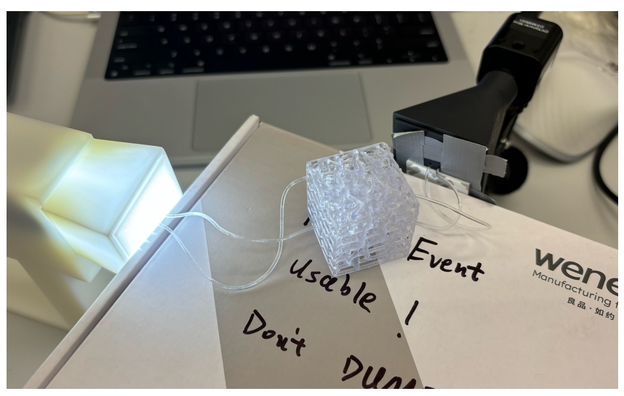
Separate the design space with multiple planes. Then propagate the planes with dots (seeds).



Use the Voronoi approach to generate struts within the design space and form the porous scaffold.

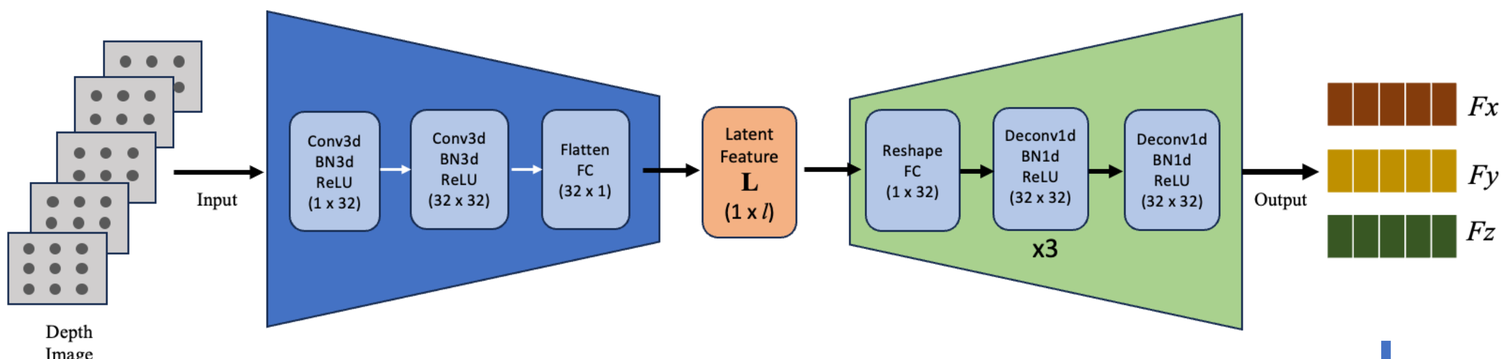
Use high-precision stereolithography (SLA) 3D-printing to produce the macroporous structure. Embed the soft optical fiber afterwards.



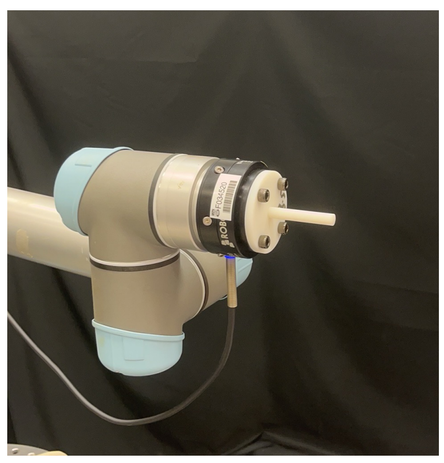


Connect the optical fibers to the stable light source and the high-speed camera.

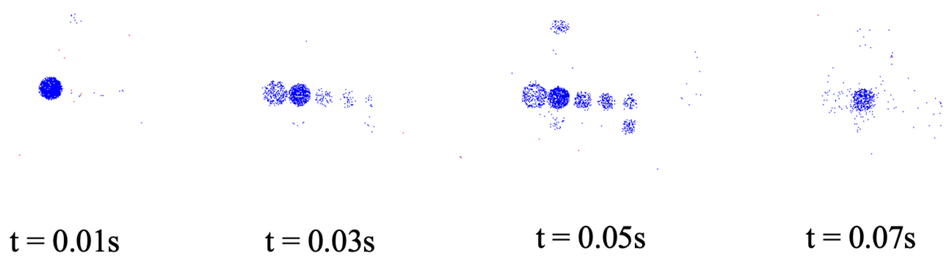
Use an encoder structure to obtain a latent feature from the depth image sequence. The latent feature is then decoded into time serials for forces in different directions.



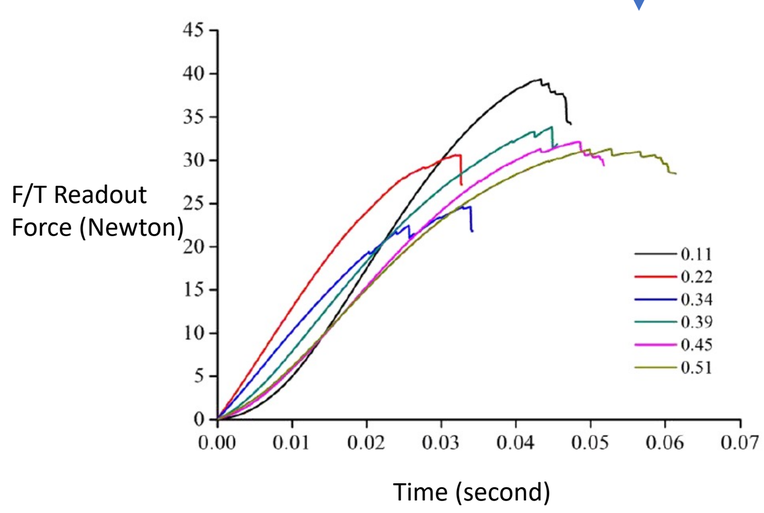
Encoder: Conv3D -> Batchnorm -> ReLU
Decoder: Deconv1D -> Batchnorm -> ReLU



Impact the sensor with the end-effector on the robot arm at multiple speeds, and record the time history of forces.



Example snapshots within the depth image sequence, showcasing the time-serial response of optical fibers.



Example history of normal force within 0.1 seconds, under different impact speeds.

ROBOTICS SCIENCE AND SYSTEMS
JULY 15–19, 2024 | DELFT UNIVERSITY OF TECHNOLOGY, NETHERLANDS