Electronic Supplementary Material (ESI) for Nanoscale.

Supplementary information

Motion recognition by a liquid filled tubular triboelectric nanogenerator

Content

Supplementary Note 1

The conductive liquid was injected by the syringe with a needle which was a little bigger than the tube. In this way, the liquid could gradually fill the tube from one end to another, remaining few air bubbles. The tube was semitransparent compared to the fulfilled one, and the liquid was not smooth to flow without external press.

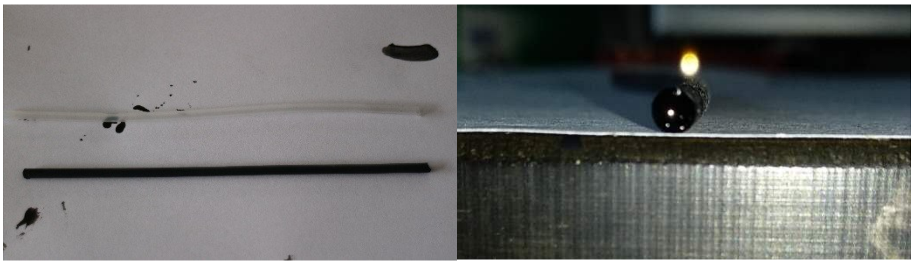

Fig. S1 Injected conductive liquid in the silicone tube.

Supplementary Note 2

There was a small residual strain for the 8 cm hollow tube after the stretching test. The residual elongation was about 0.5 cm by measuring the distance between the two dark lines. We observed that the strain concentrated on the near end of the clamp during the test. This was the reason that dark line in the right part of the photo was dim and the ink spread in a small area on the surface.

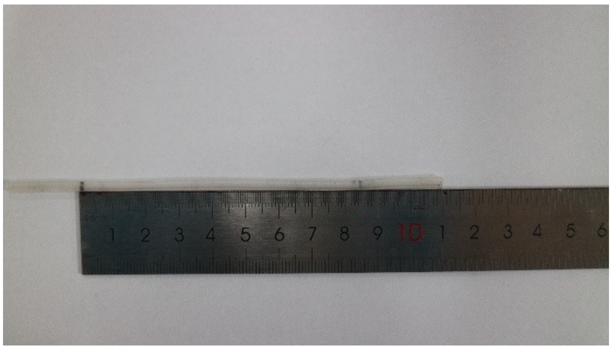

Fig. S2 Residual strain of the silicone tube after near 700% elongation test.

Supplementary Note 3

The conductivity was measured by a conductivity tester (FE38-Standard, Mettler Toledo). The conductivity of the dark ink used for experiments was 27.09 mS/cm (Figure S3a). Compared to the solution without CNTs, the conductivity was a little smaller (Figure S3b).

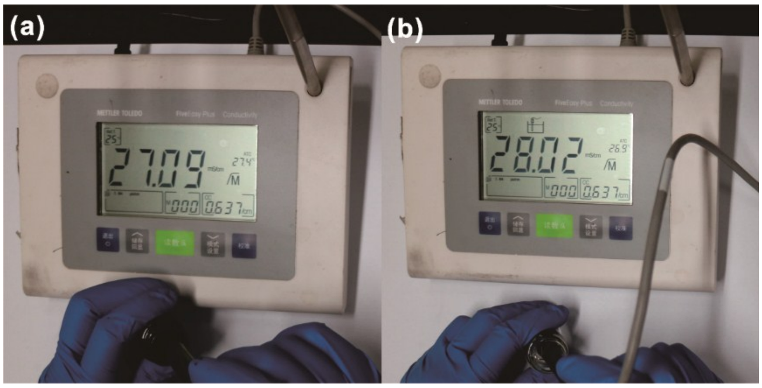

Fig. S3 The conductivity of the liquid.

Supplementary Note 4

Pressure-voltage curve of triboelectric sensing was transferred from the force-voltage curve. In fact, it was difficult to monitor the pressure during the measurement due to the active deformation. To simplify the experiments, the force was divided by the area of 2.9×8 mm^2 to obtain the pressure. The length of the CLSET tube was 2.9 mm, and the diameter of the round detector was 8 mm. This area was considered as a uniform reference for the pressure, which largely reduced the sensitivity in the low pressure region. We counted on the coarse way to find out the tendency of pressure to voltage.

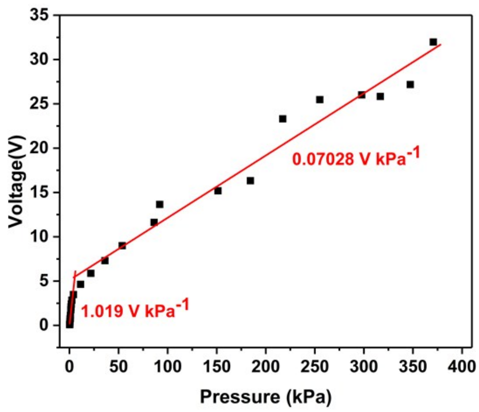

Fig. S4 Pressure-voltage curve of triboelectric sensing.

Supplementary Note 5

The CLSET was tested under the extreme strains to demonstrate its endurance to arbitrary deformation. The motions in Figure S5 caused large strains on the soft tube, and the corresponding impedance was shown on the screen. Although entwisted by fingers, the CLSET could also sense the resistance change.

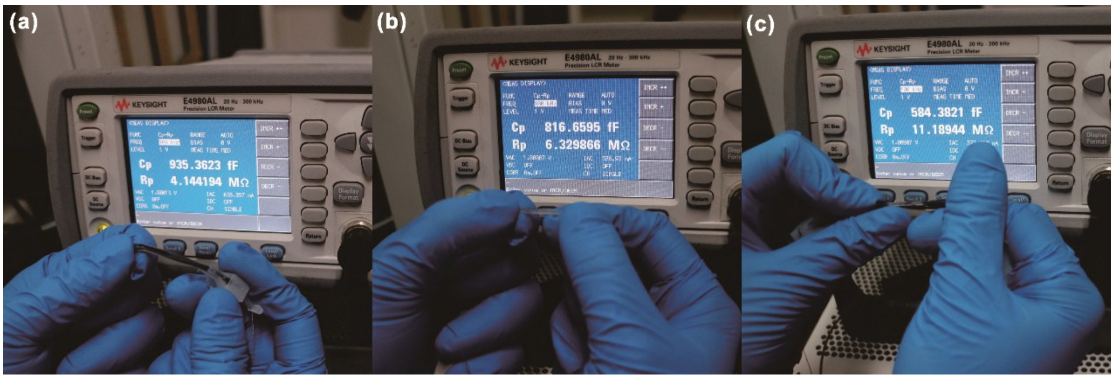

Fig. S5 The conductance of CLEST under extreme strain.

Supplementary Note 6

The resistance increased during the stretching and recovered without external force. The platform in the curve was due to the stopping time of the stretching machine before returning to the starting point.

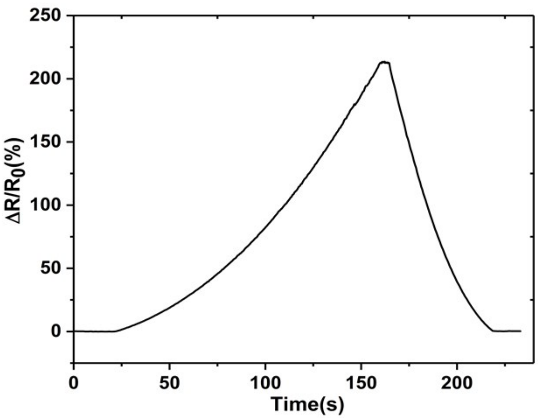

Fig. S6 The real-time curve of resistance changes to stretching.

Supplementary Note 7

The schematics of the working mechanism might be based on the electrical field around the human finger or other charged materials. It changed the local electric distribution.

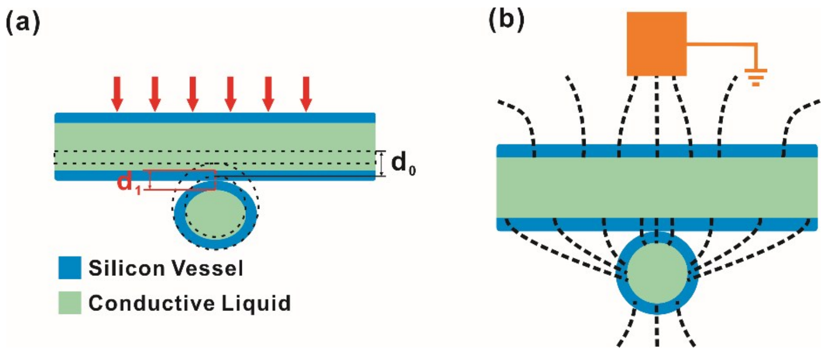

Fig. S7 Schematic illustration of the pressure and proximity sensing mechanism.

Supplementary Note 8

The geometry size of the elastic materials was shown as following. The CLSET that sustained less load resulted in larger elongation in the direction of length.

Materials	Length	Width of section	Width of section	Minimum pressure when breaking
CLSET (Dragon skin 10 silicone rubber)	70 mm	2.9 mm (outer diameter)	20 mm (inner diameter)	0.93 MPa
Latex	70 mm	29 mm	0.10 mm	11 MPa
PDMS	70 mm	20 mm	0.30 mm	7.7 MPa
TPU	85 mm	20 mm	0.37 mm	7.0 MPa (the load was beyond the bearing limit of the tensile tester)

Table S1 The geometry size of the elastic films used for stretching test compared to the CLSET device and the estimation of the minimum breaking pressure.

Supplementary Note 9

Illustration for the details of the smart motion recognition system.

There were 5 land points (4 outside and 1 inside) to distinguish the ‘‘0’’ and ‘‘1’’ in the program respectively. About 30 sets of data were collected during an experiment, and each set included three columns of data from the devices on the shoulder, wrist and elbow. The program was trained with 10 sets of them with 5 inside and 5 outside samples. The accuracy of 93% came from the probability that AI program gave to predict the landing result. All above will be added into the Supplementary Information.