ACCSCIENCE PUBLISHING

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ORIGINAL RESEARCH ARTICLE

Data-driven prediction of strain fields in auxetic structures and non-contact validation with mechanoluminescence for structural health monitoring

Supplementary Files

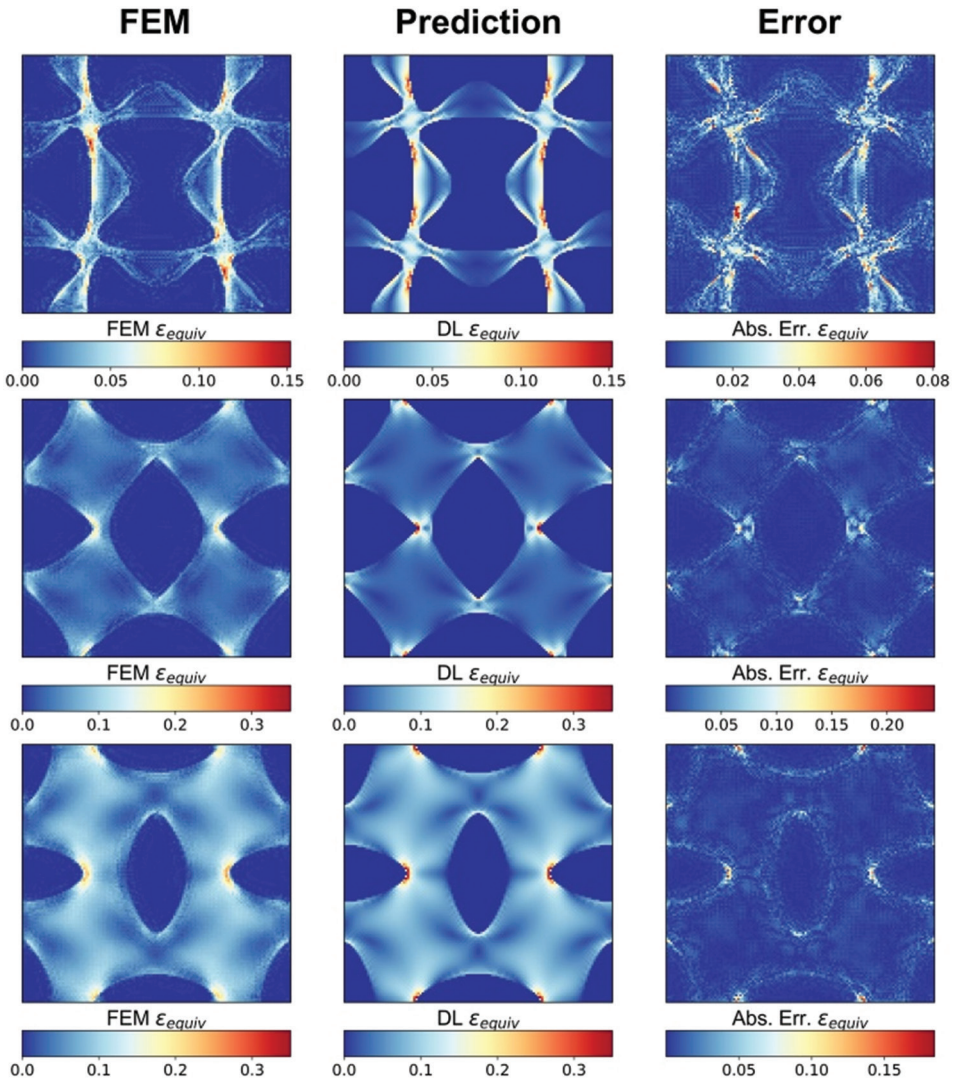

Figure S1. The comparison results between the Deep Learning (DL) model and the finite element method (FEM) for three random configurations. The results are presented under the same tensile conditions. The prediction accuracy, as indicated by the mean absolute error of DL predictions with arbitrarily chosen designs, is calculated as $1.271e^{-4}$, $2.097e^{-4}$, and $1.232e^{-4}$, respectively. The mean squared error across all 97 test sets was measured at an average of $9.464e^{-5}$, with a standard deviation of $6.962e^{-5}$.

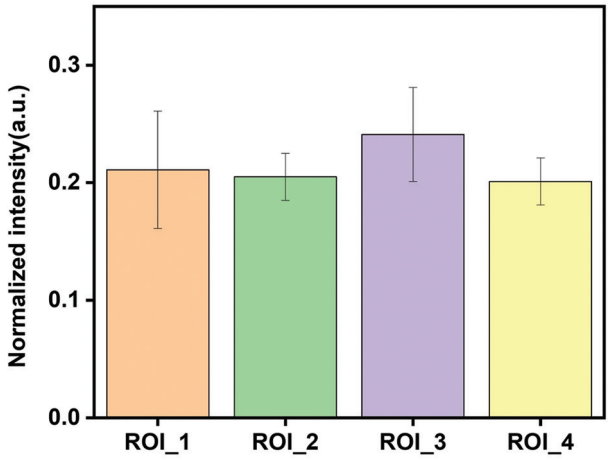

Figure S2. Results of normalized intensity in 3D mechanoluminescent (ML) tensile specimen with honeycomb structure. The region of interest (ROI) at the edges of the honeycomb specimen was extracted, and normalized intensity was presented at a global strain of 0.4%. The results exhibited variations in intensity within each ROI but remained consistent with the ML trend.

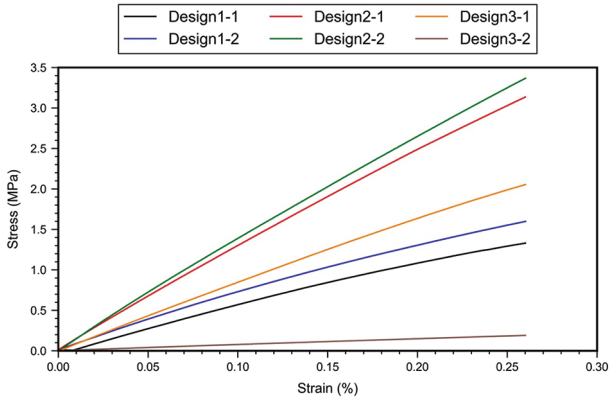

Figure S3. Stress–strain curve with specimen with designed structure

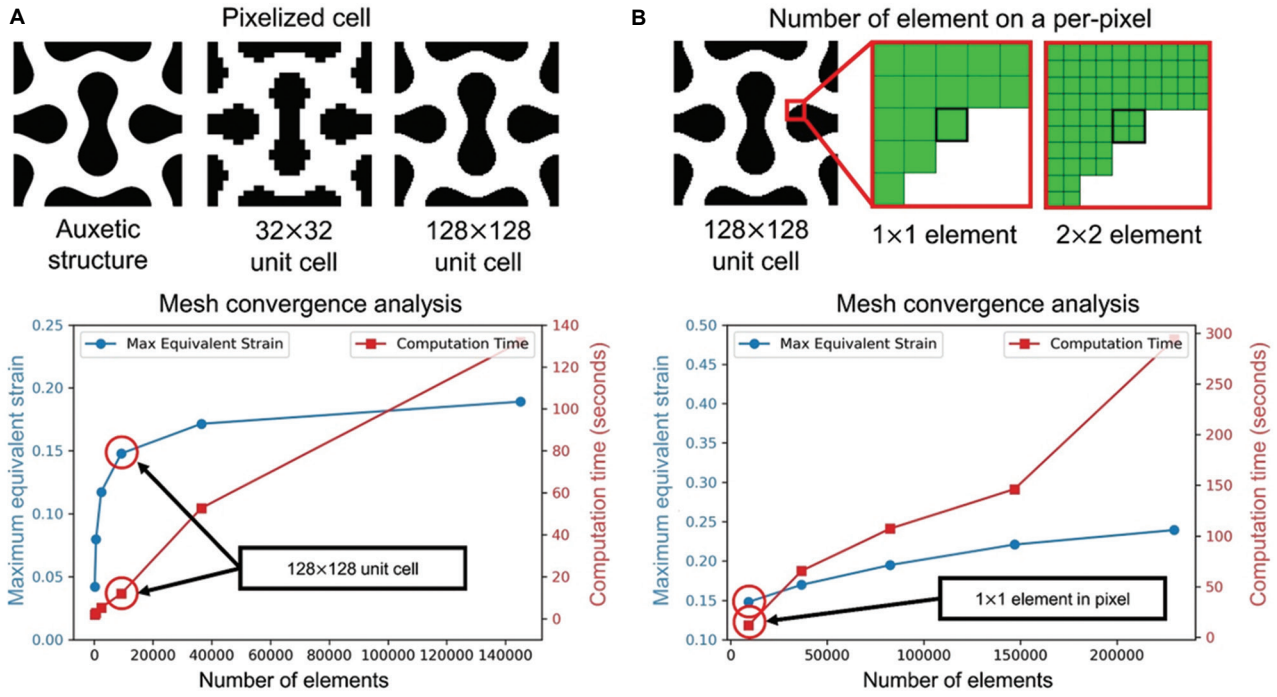

Figure S4. Mesh convergence study results: (A) The configuration of pixelized unit cell and mesh convergence result for pixelization of auxetic structure, and (B) the element configurations per pixel within the 128 × 128-unit cell and mesh convergence result for per-pixel element density.

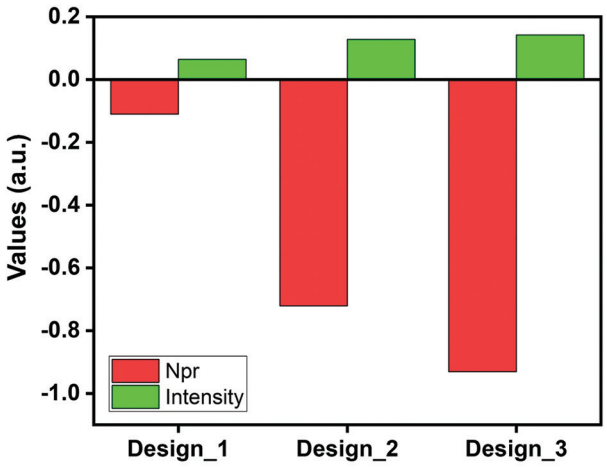

Figure S5. Results of negative Poisson's ratio values and normalized intensity under tensile condition

Table S1. Mesh convergence results for each unit cell

Conditions	16 × 16	32 × 32	64 × 64	128 × 128	256 × 256	512 × 512
Number of elements	144	576	2,352	9,184	36,444	145,119
Maximum equivalent strain	0.042	0.080	0.117	0.148	0.172	0.189
Computation time (s)	2.0	2.8	5.2	11.9	52.7	131.9

Table S2. Mesh convergence results per pixel in the 128 × 128-unit cell

Conditions	1 × 1	2 × 2	3 × 3	4 × 4	5 × 5
Number of elements	9,184	36,736	82,656	146,944	229,600
Maximum equivalent strain	0.148	0.170	0.195	0.221	0.240
Computation time (s)	11.9	65.6	107.3	146.2	294.0