Data-driven exploration of a supercompressible metamaterial

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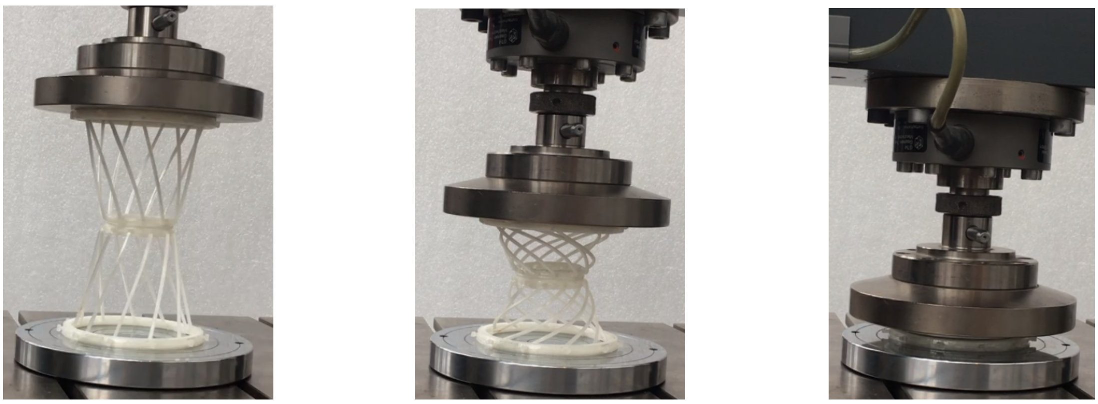
Background

For years, creating new materials has been a time consuming effort that requires significant resources because we have followed a trial-and-error design process. Now, a new paradigm is emerging where machine learning is used to design new materials and structures with unprecedented properties. Using this data-driven process, a new super-compressible metamaterial was discovered despite being made of a fragile polymer.

Figure 1 shows the newly developed metamaterial prototype that was designed with the above-mentioned computational data-driven approach [1] and where experiments were used for validation, not discovery. This enabled the design and additive manufacturing of a lightweight, recoverable and super-compressible metamaterial achieving more than 90% compressive strain when using a brittle base material that breaks at around 4% strain. Within minutes, the machine learning model was used to optimize designs for different choices of base material, length-scales and manufacturing process. Current results show that super-compressibility is possible for optimized designs reaching stresses on the order of 1 kPa using brittle polymers, or stresses on the order of 20 MPa using carbon like materials.



(a) Undeformed metamaterial (b) 50% deformation. (c) More than 90% deformation

Figure 1: 3D printed super-compressible metamaterial designed with machine learning.

This final project focuses on finding good machine learning models to design this metamaterial using a data-driven framework [1].

Start your machine learning investigation by focusing on training different machine learning algorithms and evaluating which ones are better suited for this problem.

Regression problems (i.e. prediction of the critical buckling load and the energy absorbed):

1. **Before** start doing anything else, please make sure that you understand your data well (i.e. data pre-processing).
2. Fit at least **3 regression models** (one model from the paper to replicate the paper results and other two models to get better performance) to your data.
3. Compare the performance of the trained models and select the best regression model.
4. Compare the best solutions found for each problem.

P.S. Groups which provide the best performances for regression will be rewarded.

References

[1] M.A. Bessa, P. Glowacki, and M. Houlder. Bayesian machine learning in metamaterial design: Fragile becomes supercompressible. *Adv. Mater.*, 0(0):1904845–, October 2019.