Machine Learning for the Inverse Design of Topologically Protected Phononic Beams

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Phononic crystals and metamaterials have seen tremendous amount of research studies in the recent past for its peculiar wave dispersion and dynamic properties that cannot be conceived from naturally occurring materials. Such type of synthetic structures induce bandgap that is a frequency region where wave propagation is prohibited. The frequency bandgap region is identified by wave dispersion curve that is constitutive relation between wavenumber and eigenfrequency. Bandgap in phononic crystal and metamaterial is manipulated in several ways for sound insulation [1], vibration mitigation [2], waveguiding [3], wave focusing [4], topological properties [5] and trapped rainbow effect [6]. Recently, topological properties in phononic crystal has witnessed a surge of research studies due to topologically protected interface modes that facilitates in providing robust, immune to backscattering wave propagation at the interface mode frequencies. In this work, we employed transfer matrix method along with Euler-Bernoulli beam theory to obtain the constitutive relation for bending and longitudinal elastic waves in 1-D phononic crystal system. Then machine learning algorithm is developed and by using the constitutive relation, the input data is generated to train the network. The geometric Zak phase for topologically protected beams are calculated and this information is passed to the network to distinguish trivial and non-trivial eigenmodes. The network is able to predict the trivial and non-trivial edge modes and can output explicit geometric parameters to observed interface modes. The network performance is validated by comparing our findings with transfer matrix methods and numerical codes. Excellent agreement is observed. The study findings will introduce a new perspective on application of machine learning methods in solid mechanics and topological phononic crystals.

References