From Natural Science to Information Science and Back

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ABSTRACT

The arrival of massive amounts of data from imaging, sensors, computation and the internet brought with it significant challenges for information science. New methods for analysis and manipulation of big data have come from many scientific disciplines. Most recently, the flow of ideas has reversed as new information theoretic methods are being harnessed for the natural sciences. The first example is variational principles, originally developed for mathematical modeling of physical phenomena but then used for image and data analysis, as in compressed sensing. The resulting ideas of soft-thresholding and sparsity are now being applied back to PDEs. A second example is neural nets, which derive from neurological models and form the basis for deep-learning and related machine learning techniques. These have been remarkably successful for applications such as voice, handwriting and facial recognition. Recently, machine learning algorithms have been used to mine datasets of structural and electronic properties for known materials, in order to predict the corresponding properties of hypothetical materials. The third, not so new example is entropy, which was developed in thermodynamics and statistical mechanics, then used by Shannon for analysis of communication channels. Now, information theoretic entropy is being used for closure of multiscale methods in plasma physics.