Visualizing the clustering transition using unsupervised learning

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We study the solutions of two random boolean satisfiability problems 3-SAT and XORSAT using recently developed machine learning techniques. We use non-linear embedding techniques to learn the local manifolds in which the solutions organize. In particular we provide, to the best of our knowledge, the first visualizing of the so-called clustering transitions that are known to occur in those problems. Finally, using unsupervised clustering methods we are able to automatically extract quantities such as the entropy of clusters.

Landscape induces complexity, but not always : [1]

I. INTRODUCTION

Chris Moore discussion, etc. cite Mzard, stat. phys. and yourself.

II. MODEL & METHODS

XORSAT, 3-SAT. BP, SP and Gaussian elimination.

A. t-SNE

B. Density clustering

C. Results and Discussion

Spin glass models such as the Sherrington-Kirkpatrick model or the Anderson model are known to be NP-complete [2]. Consequently it is believed that no algorithm can be devised in order to compute the ground-state in a time scaling polynomially with the system's size. Much work has been made in trying understanding what makes a problem hard from a statistical mechanics point of view. In particular, in random satisfiability problems such k-SAT and XORSAT the onset of a glass transition has been associated with the appearance of frozen variables and clustering in the solution space, which has been conjectured to induce failure of local search algorithms [3]. Note that glassiness does not necessarily imply hardness to solve. Phenomenologically, it appears that for glassy problems, any local search/stochastic method will fail, i.e. finding the ground-state is exponential in the system size. However, if one is able to devise some global method based on non-local updates, then some glassy problems are known to be in P. This is the case for instance of XORSAT (equivalent to solving a linear system mod 2) which can be efficiently solved using gaussian elimininination [1].

a. Clustering XORSAT, 3-SAT

b. Entropy via density clustering Relation to complexity and broader applications in stat. mechanics.

III. CONCLUSION

Packages are available for t-SNE and efficient clustering available at alexandreday github

IV. ACKNOWLEDGEMENTS

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[3] C. Moore and S. Mertens, The nature of computation (OUP Oxford, 2011).

Supplemental Material

V. DENSITY CLUSTERING VIA KERNEL DENSITY ESTIMATES