

Monte Carlo Simulation on Spin Glass

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Abstract—Spin Glass is a very complex physical material in nature. It exhibits high magnetic frustration, which causes the system to have a rough free energy landscape. Besides its importance in condensed matter physics, spin glass behavior applied to neural network, computer science, econophysics, etc.

Index Terms—Spin Glass, Ising Model, Monte Carlo, Condensed Matter Physics Modeling

I. INTRODUCTION

As the computation power of computer grows rapidly, more and more physical material can be modeled theoretically with the computer. This leads us to a whole new field, since there are way too many restriction s on what a practical experiment can do. One of the complex physical behavior is spin glass. The following figure is spin glass at a random magnetic moments,

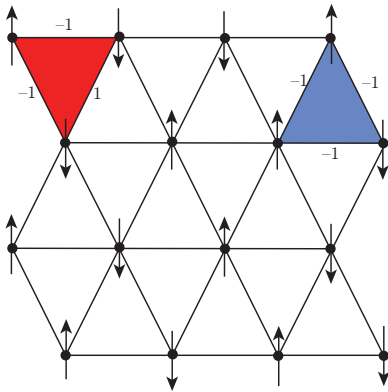


Figure 1. Spin Glass with random spins and bonds

In the figure, each dot represent an atom which I will refer as site. Each arrow is a magnetic dipole or spin on each site. The spin is each up or down. The lines between any two sites is the magnetic bond between the two sites. There are only two kinds of bonds, ferromagnetic bonds and paramagnetic bonds, and they are labeled 1 and -1 in the figure. The ferromagnetic bond wants the its two sites have the same spin, while the paramagnetic bonds tries to have opposite spins on its two sites. I am working with the triangular formation, and we can see in the red triangle, all three bonds are satisfied. On the other hand, the blue triangle does not satisfy its bonds, in fact, it will never reach a configuration to satisfy all the paramagnetic bonds. And this is called frustration. Spin glass is a disordered system with high magnetic frustration. Since each bond tries to force the unmatched spin to flip, the frustrations causes the system unable to remain in a single lowest energy state, the ground state, instead, the spin glass

system has multiple energy local minima. Actually, the internal energy of a system is calculated by the Hamiltonian

$$H = - \sum_{\langle ij \rangle} J_{ij} s_i s_j,$$

where the variables J_{ij} are the random bond strengths, and s_i are the spin on site i , 1 for up-spin and -1 for down-spin.

II. WEEK 2 REPORT

After reading the book *Monte Carlo Methods in Statistical Physics* and *Spin Glasses*, I have started on the coding part of my project. Tom, one of the Ph. D student on this project, gave me his code which has the implementation of Monte Carlo simulation. I spent my week to learn his code and modified parts of the code as I was implementing. I also need to add the Overlay functions to find the relationship between the energy local minima. The base equation for Overlay function is

$$Overlay = \frac{\sum_i m_i^a m_i^b}{|m^a| \cdot |m^b|},$$

where m_i^a is the average magnetization of each site in configuration a , and $|m^a| = \sqrt{\sum m_i^2}$. Right now, I am in the process of coding such function. The obvious way to store the magnetization data is using double array, which makes the program very slow. As the lattice size or the Monte Carlo steps getting larger, the program would take hours to run. I will try to find an alternate data structure to store the data. Next week, I will be finishing up with the Overlap implementation. And I will start learning Matlab so that I will be able to visualize the result I get from my program. The visualization will also allow me to analysis the data and be able to present any result to my group members. The other plan I have is to read more articles on spin glass, especially on the networking aspect of it. I'd like to join the two Ph.D students in the near future on their projects. [1], [2], [3]

REFERENCES

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