说明：

图表, 折线图, 直方图

描述已自动生成

我取N=15，R=0.5，K=3，p=0.05，beta=0.5log((1-p)/p)，根据公式进行迭代50次之后，得到上图。其中准确率在1和0.33之间震荡，0.33对应的是所有自旋磁化m均为0的解。在一些其他参数的迭代结果中，经常会收敛到所有自旋磁化m均为0的解。

将beta从0.5log((1-p)/p)变为log((1-p)/p)后，算法似乎可以稳定收敛到正确解，见下图。

图表, 直方图

描述已自动生成

Python代码附录如下：

import numpy as np  
import matplotlib.pyplot as plt  
np.random.seed(1)  
N = 15 *# number of spins*R = 0.5  
M = int(N / R) *# number of interactions*K = 3 *# number of spins per interaction*p = 0.05 *# flipping prob*beta = np.log((1-p)/p)/2 *# inverse temperature*num\_step = 50  
  
xi = np.random.choice([-1,1],size=N) *# original message*Ja\_ori = np.zeros([M])  
conn\_N = [[] for \_ in range(N)] *# which connects to a spin*conn\_M = [] *# which connects to an interaction*for Ja\_idx in range(M):  
 spins\_Ja = np.random.choice(N,size=K, replace=False)  
 conn\_M.append(spins\_Ja)  
 for spin in spins\_Ja:  
 conn\_N[spin].append(Ja\_idx)  
 Ja\_ori[Ja\_idx] = np.product(xi[spins\_Ja]) *# (2.5)  
# print(conn\_N)  
# print(conn\_M)*Ja = Ja\_ori \* np.random.choice([-1,1],p=(p, 1 - p), size=M) *# (2.6)*U\_ai = np.random.rand(M, N)  
H\_ia = np.random.rand(N, M)  
m = np.zeros([N])  
acc\_list = []  
for t in range(num\_step):  
 U\_ai\_new = np.zeros([M, N])  
 H\_ia\_new = np.zeros([N, M])  
 for i in range(N):  
 sum\_U\_bi = np.sum(U\_ai[conn\_N[i],i])  
 for a in conn\_N[i]:  
 H\_ia\_new[i,a] = sum\_U\_bi - U\_ai[a,i]  
 for a in range(M):  
 for i in conn\_M[a]:  
 prod = 1  
 for k in conn\_M[a]:  
 if k!=i: prod \*= np.tanh(beta \* H\_ia[k, a])  
 U\_ai\_new[a,i] = 1/beta\*np.arctanh(np.tanh(beta\*Ja[a])\*prod)  
 U\_ai, H\_ia = U\_ai\_new, H\_ia\_new  
 *# print('U',U\_ai)  
 # print('H',H\_ia)* for i in range(N):  
 m[i] = np.tanh(np.sum(beta \* U\_ai[conn\_N[i],i]))  
 xi\_dec = (m>0)\*2-1  
 acc = np.mean(xi\_dec==xi)  
 acc\_list.append(acc)  
 print(**'step'**,t, **'m'**,m,**'xi\_dec'**,xi\_dec, **'xi'**, xi, **'correct'**, acc)  
plt.plot(range(num\_step), acc\_list)  
plt.xlabel(**'Iteration'**)  
plt.ylabel(**'Accuracy'**)  
plt.show()