17 - 19 Hopfield NN for QAP with Switching Noise Including Various Time Series

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1. Introduction

Several people proposed the method adding chaos noise to the Hopfield Neural Network (NN) for combinatorial optimization problems. In this study, we investigate solving ability of Hopfield NN for QAP when the chaotic behavior of the switching noise is changed.

2. Solving QAP with the Hopfield NN

For solving N-element QAP by the Hopfield NN, $N \times N$ neurons are required and the following energy function is defined to fire (i,j)-th neuron at the optimal position:

$$E = \sum_{i,m=1}^{N} \sum_{j,n=1}^{N} \omega_{im;jn} x_{jn} + \sum_{i,m=1}^{N} \theta_{im} x_{im}. \quad (1)$$

The states of $N \times N$ neurons are asynchronously updated due to the following difference equation:

$$x_{im}(t+1) = g\left(\sum_{i,n=1}^{N} \omega_{im;jn} x_{jn}(t) + \theta_{im} + \beta z_{im}(t) \right). \quad (2)$$

z_{im} is additional noise, and β limits amplitude of the noise.

3. Chaotic Switching Noise

The cubic map is used to generate chaotic switching noise.

$$\hat{z}_{im}(t+1) = -\hat{z}_{im}(t)(\alpha \hat{z}_{im}^2(t) + 1 - \alpha). \quad (3)$$

We inject the chaotic switching noise to the Hopfield NN, we normalize $\hat{z}_{im}$ by Eq. (5)

$$z_{im}(t) = \frac{\hat{z}_{im}(t) - \bar{z}}{\sigma_z} \quad (4)$$

where $\bar{z}$ is the average of $\hat{z}(t)$, and σ_z is the standard deviation of $\hat{z}(t)$.

In this study, the amplitude parameter of the injected noise is fixed as $\beta = 0.55$. The chaotic switching noise is shown in Fig. 1. The horizontal axis is time and the vertical axis is the value of the chaotic switching noise.

4. Switching Random and Torus Noise

In the previous research, we have confirmed that regular switching between the two parts the performance worse. Hence, the former chaotic feature can be said to be important for solving QAP. How about the latter chaotic feature? And so, we replace the chaotic time series inside the each interval of the chaotic switching noise by random and torus noise. The obtained switching and torus noise are shown in Fig. 2.

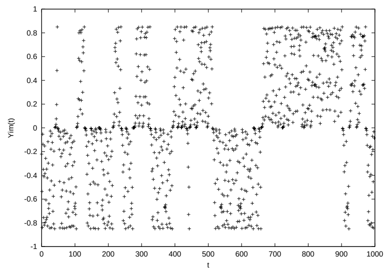
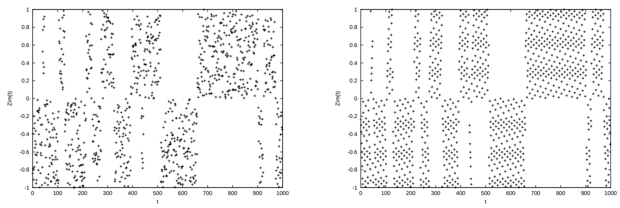


Figure 1: Torus noise.



(a) Switching random (b) Switching torus

Figure 2: Switching noise.

5. Simulated Results

The problem used here was chosen from the site QAPLIB named "Nug12." The global minimnm of this target problem is known as 578. The total number of updating the network is 10000.

The results are summarized in Table 1. The results show that the switching random noise has much better performance than the switching torus noise. and it gain similar performance to the cubic map.

Table 1: Iteration and mean solution.

iteration	random	torus	cubic
2000	627.4	656.6	625.4
4000	617.8	654.8	615.8
6000	613.6	654.4	614.6
8000	613.4	654.4	608.8
10000	611.8	654.4	606.6

6 Conclusions

In this study, we investigated performance of the switching random and torus noise injected to the Hopfield NN for QAP. We confirmed that chaotic behavior inside the each interval is not important but some kinds of irregularity are necessary.