§ 24. Tomographic Image Reconstruction by Hopfield Neural Network

Iwama, N. (School of Informatics, Daido Institute of Technology)
Okada, N. (Dept. Electronics and Informatics, Toyama Kenritsu Univ.)
Hosoda, Y. (Dept. Information Science, Fukui Univ.)

The Hopfield neural network was studied in application to the tomographic image reconstruction of plasma. Application can be made by letting the energy function of the neural net be the equal of the Lagrangian function [1] to be minimized in Tikhonov-Phillips regularization.The equalization leads to a Hopfield system: the neurons as many as pixels are interconnected by proper weights which depend on the projection matrix, that is, the geometry of the sight-lines of camera system, and also on two numerical appliances of Tikhonov-Phillips, that is, the regularization parameter and the smoothing operator. The projection data (detector signals) are given to the system as neuron biases in form of the back projection of tomography. When the dynamics of the neural system so-designed is computer simulated, the system changes so as to decrease its energy function and reaches a stable state of minimum energy that is determined by the given biases and interconnection weights.

Test was made on the Hα emission tomography data of the small tokamak CSTN-III of Nagoya University, that is, the image reconstruction problem with 600 lines of sight (3 fan-beams) and 30x30 pixels [2]. As seen in Fig. 1, each neuron is negatively connected with itself and with the other neurons which exit on the lines of sight which pass itself, and positively connected with neigboring neurons due to the Laplacian operator for image smoothing. The positive connections with neighboring neurons are strengthened as the reguraization parameter γ (>0) is increased.

With appropriations in both the sigmoid function parameter and the temporal discretization, asynchronous updating of the neuron states gave a monotonical decrease of the energy function E (the Lagrangian function) as shown in Fig. 2, and reached a practical convergence in the plasma image shown in Fig. 3, whose pixel values were obtained as the outputs of the neurons. This Hopfield minimization of the Lagrangian function is carried out with constraint of the sigmoid function, which is non-linear and keeps the pixel values always positive.

This result in Figs. 2 and 3 was obtained using the reconstructed image of Tikhonov-Phillips (the solution of the linear minimization) for an initial state of the neurons. Problem remains in sight-line missing region, where the pixel value updating is slow owing to a weak inter-connection of the neurons.

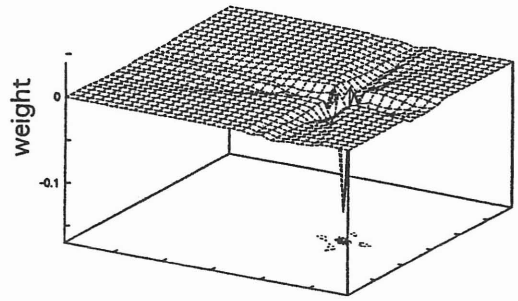

Fig. 1. Interconnetion weights to the 412nd neuron, that is, the (14, 22) pixel, which is passed by lines of sight. Display in 30x30 image region; γ=2.0x10^{-3}.

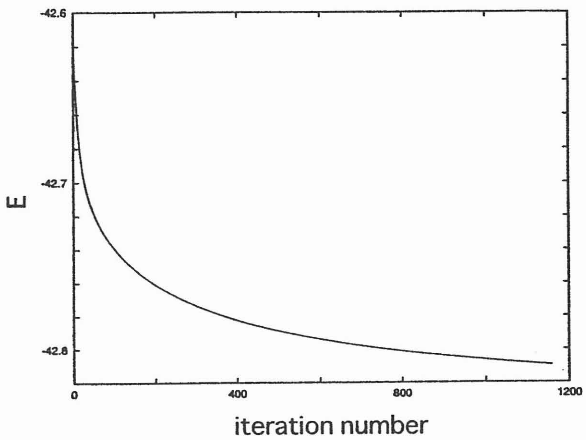

Fig. 2. Change of the energy function E with the number of iteration for a set of projection data;γ=1.0x10^{-2}.

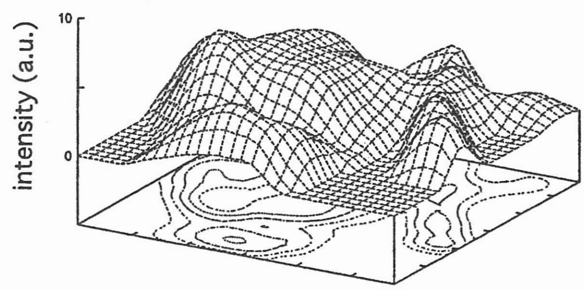

Fig. 3. Reconstructed image in poloidal section with 30x 30 pixellation of 16x16 cm^2 region (view from the side of a sight-line missing region); γ=1.0x10^{-2}.

References

1) Terasaki, N., Iwama, N. and Hosoda, Y., Trans. IEICE **J81-D-II**, (1998) 93.
2) Shen, Y., Takamura, S., Iwama, N. et al., Nuclear Fusion Research **59**, (1988) 30.