2006 IEEE Workshop on Nonlinear Circuit Networks (NCN'06)
Tokushima University, Tokushima, Japan, Dec. 9, 2006

The Range to Generate Phase-Wave Phenomena in 1-Dimension 2-Layer Cellular Neural Networks

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***Abstract*— 2-layer CNNs can exhibit phase-wave propagation phenomena by choosing an appropriate set of the parameters. For deeper analysis, we compare a range of parameters to generate phase-wave-propagation phenomena in 2-layer CNNs and van der Pol oscillatros. We research a range of parameters to generate phase-wave-propagation phenomena in 2-layer CNNs.**

I. Introduction

Celluar Neural Networks (CNN) are constructed by cells connected each other. The cell contains linear and nonlinear current sources controlled by voltage. Already a lot of applications and VLSI implementations of CNN was reported. Many nonlinear phenomena such as pattern formation and autowaves could be observed in CNN. Investigating the nonlinear phenomena is an important work for clarifying dynamics of CNNs. On the other hand, phase-wave propagation phenomena in van der Pol oscillators coupled by inductors were reported. It is known that 2-layer CNNs can exhibit phase-wave propagation phenomena by choosing an appropriate set of the parameters.

Therefore, for deeper analysis, we compare a range of parameters to generate phase-wave-propagation phenomena in 2-layer CNNs and van der Pol oscillatros. In this work, we report range of parameters in modified 2-layer CNNs.

II. Modeified 2-Layer 1-Dimension CNN

In this study, we use modified 1-dimensional 2-layer CNN. The circuit equations governing the modified CNN are written as

$$\dot{x_{1,k}} = -x_{1,k} + a_1 y_{1,k} + c_1 x_{2,k} + d_1 y_{2,(k-1)} + d_1 y_{2,(k+1)} \quad (1)$$

$$\dot{x_{2,k}} = -x_{2,k} + a_2 y_{2,k} + c_2 x_{1,k} + d_2 y_{1,(k-1)} + d_2 y_{1,(k+1)} \quad (2)$$

$$y_{\ell,k} = f(x_{\ell,k}) = 0.5\left(|x_{\ell,k}+1| - |x_{\ell,k}-1|\right) \quad (3)$$

$$(k = 1, 2, \cdots, N, \quad \ell = 1, 2)$$

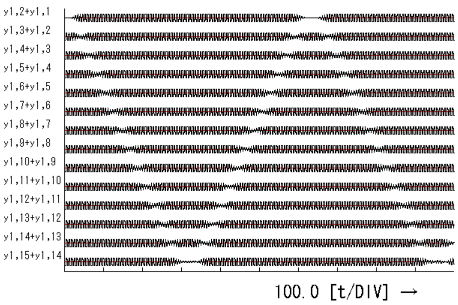
where $x_{\ell,k}$ is the state, $y_{\ell,k}$ is the output of CELL$_{\ell,k}$, a_ℓ, c_ℓ, and d_ℓ are the feedback parameters from the output of its own cell, from the output of the cell which is at the same position in the other layer, and from the output of the neighborhood cell in the other layer, respectively.

In this modified CNN at $a_1 = 1$, $c_1 = 1$, $d_1 = 0$, $a_2 = 1.2$, $c_2 = -1.2$, and $d_2 = 0.10$, we can observed phase-wave propagation phenomena.

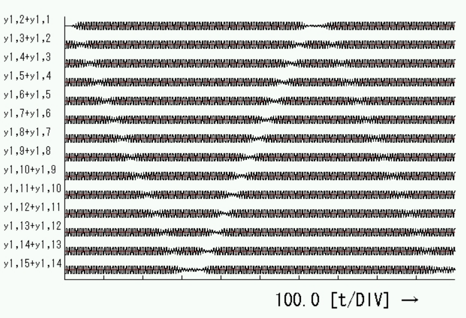
III. Simulation Result

We try to observe the phase-wave propagation phenomena when a_2 is changed into every 0.1 from 1.0.

At $a_2 = 1.0$, we cannot observe the phenomena. At $1.1 \leq a_2 \leq 2.0$, we can observe the phenomena shown as Fig. 1(a). At $a_2 \geq 2.1$, we cannot observe the phenomena shown as Fig. 1(b).



(a) At $a_2 = 2.0$.



(b) At $a_2 = 2.1$.

Fig. 1. Simulation Results

IV. Conclusions

In this report, we research a range of a_2 to generate phase-wave propagation phenomena. In future work, we will compare with phenomena in van der Pol Oscillators coupled by the inductors.