Seismic wave propagation modelling on emulated digital CNN-UM architecture

Péter Kozma

The solution of partial differential equations (PDE) has long been one of the most important fields of mathematics, due to the frequent occurrence of spatio-temporal dynamics in many branches of physics, engineering and other sciences. One of the most exciting areas is the simulation of seismic wave propagation. It is an important tool to understand wave-field phenomena and how it relates to observations of recorded seismic data. An important aspect of an earthquake is the stresses and deformations of the ground. On the other hand the solution of these equations requires enormous computing power. In this paper a CNN-UM simulation of seismic wave propagation will be presented. Unfortunately the space-dependent equations do not make it possible to utilize the huge computing power of the analogue CNN-UM chips. To improve the performance of our solution an emulated digital CNN-UM is used.

A Cellular Neural Network is a non-linear dynamic processor array. Its extended version, the CNN Universal Machine (CNN-UM), was invented in 1993 [1]. The CNN paradigm is a natural framework to describe the behaviour of locally interconnected dynamical systems which have an array structure. So, it is quite straightforward to use CNN to compute the solution of partial differential equations (PDE). Several studies proved the effectiveness of the CNN-UM solution of different PDEs [2], [3]. But the results cannot be used in real life implementations because of the limitations of the analogue CNN-UM chips such as low precision or the application of space-dependent templates. Emulated digital CNN-UM architectures seem to be more flexible than their analogue counterparts both in cell array size and accuracy while their computing power is just slightly smaller. In this paper a method is given to model the propagation of stress waves in two-dimensional inhomogeneous elastic medium on CNN-UM architectures.

References

[1] T. Roska and L. O. Chua: "The CNN Universal Machine. An analogic array computer", IEEE Trans. On Circuits and Systems-II, Vol.40, pp. 163-173, 1993.

[2] T. Roska, T. Kozek, D. Wolf, L. O. Chua: "Solving Partial Differential Equations by CNN" Proc. of European Conf. on Circuits Theory and Design, 1992.

[3] P. Szolgay, G. Vörös, Gy. Eross: "On the Applications of the Cellular Neural Network Paradigm in Mechanical Vibrating System", IEEE. Trans. Circuits and Systems-I, Fundamental Theory and Appl., vol. 40, no. 3, pp. 222-227, 1993.

[4] K. R. Kelly, R. W. Ward, Sven Treitel and R. M. Alford, "Synthetic Seismograms: a Finite-Difference Approach", Geophysics, Vol. 41. No. 1. pp. 2-27, 1976.