Cellular Neural Network Computational Scheme for Efficient Implementation of the FDTD method

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A Cellular Neural Network (CNN) computational scheme is a processor array structure that emulates the most valuable parallelizing capabilities of the Artificial Neural Network (ANN) (L. Chua, L. Yang, Circuits and Systems, IEEE Tran, 1988). Each cell or processor inside the array has a specific processing capabilities depending on the mapped numerical application over it. This scheme has been proved in different applications that assure a PDE regular mesh mapping (A. Kiss, Z. Nagy, Journal of Circuit Theory and App, 2008).

The FDTD method could make explicit a regular geometry mapping of the Maxwell PDEs (M. Balsi, A. Marongiu, ECCTD95, 1995) and it is considered the most practical numerical method to evaluate electromagnetic applications. However, FDTD demands high computational cost in terms of spatial density and timestepping (B. Zhu, J. Chen, ICMTCE, 2011) when realistic cases involve high densities to capture correctly all geometries (i.e, curves or oblique objects). Consequently, these high densities scenarios require a large number of variables implying more memory allocation space and expensive computational cost.

In this work, we have studied an alternative parallel implementation using the CNN scheme based on Single Instruction Multiple Data (SIMD) structure. This structure could be addressed easily into a CNN array assigning only one task to each processor, which is flexible enough to be implemented on MPI. The MPI and the sequential evaluation have been meausured taking into account performance metrics (i.e speedup, throughput and execution time) (M. Saldana, A. Patel, HPRCTA, 2008). This new MPI+CNN FDTD implementation scheme allows to define data initialization and inter-processor communication models. (i.e, binary tree scheme or neighbors ID verification). The sequential and parallelized FDTD have been validated using some commercial and open software such as Meep, openEMS and WCT showing the advantages of the proposed structure.