2. CELLULAR WAVE COMPUTING AND SPATIAL-TEMPORAL ALGORITHMS

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The Cellular Wave Computing paradigm emerged as a new kind of computer, an algorithmically programmable spatial-temporal computer. Its spatial-temporal elementary instruction was the dynamics of a Cellular Nonlinear Neural Network (CNN) composed of simple nonlinear dynamic cells and local interaction patterns. These elementary instructions were combined algorithmically to form the CNN Universal Machine. Soon, a broader class of cell dynamics and local interaction patterns were introduced. A new kind of algorithmic thinking has developed and the first mixed-signal integrated circuit implementations appeared.

Right at the beginning of this new kind of computing principles, the neurobiological inspiration, in particular the retinal research and the visual pathway, was important. Actually, several cellular wave computing models had been developed following the new discoveries in retinal research.

The formal description of the algorithms on a Cellular Wave Computer had been defined as the alpha-recursive functions.

The arrival of commercially available cellular visual microprocessors (Eye-RIS of AnaFocus Ltd., Bi-i of Eutecus Inc., and Smart Photo Sensor of Toshiba Corp.) make this new computing paradigm a practical alternative for very low power, small form factor, and high computing power, high frame rate applications.

Nano-scale electronics technologies, both CMOS and beyond CMOS, provide the means to fabricate massively parallel systems with thousands or millions of processors/cores in a small package, as well as in low-power versions. Most of these architectures contain cellular or multi-cellular architectures where the precedence of geometric and logical locality is a must. The cells might vary both in function as well as in their modes of operation, including arithmetic or analog, logic, and symbolic cells, as well as integrated sensory elements. In the whole operation, the interplay between local dynamics and global dynamics plays an increasingly important role. The maturity of 3D integration technologies provides another mechanism for complexity and efficiency increase.

In addition to the architectural innovations and algorithmic mappings, the basic spatial-temporal dynamics in the Cellular Wave Computers are becoming more complex *leading to surprisingly new theoretical and practical results*, as well. This means that even the elementary spatial-temporal instructions of the CNN dynamics become more complex. In particular,

i) the spatial-temporal input will be dynamic even in a Cellular Automaton,

ii) one or more spatial-temporal waves defined by templates is used for a continuous dynamic input without breaking it into discrete-time frames, and the qualitative differences of the spatial-temporal output will code the input features (frameless computing), and

iii) oscillatory cells are used in a global synchronization mode, where the elementary computational primitive is a spatial-temporal synchronization effect.

In addition to these theoretical challenges, practical challenges emerge:

i) the implementation of non-topographic problems (like particle filters),

ii) the sense and avoid problems in avoiding the collision of a UAV and a bigger airplane,

iii) the architectural solutions for beyond CMOS nano-electromagnetic technologies, e.g. informing associative memories, the specific use of nanomagnetic components and integrated systems (like Spintronic Oscillators and static nanomagnets).

REFERENCES AND A FULL RECENT OVERVIEW CAN BE FOUND IN

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