Guest Editors’ Introduction:

BIOLOGY-INSPIRED CIRCUITS

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Although digital circuits are replacing analog circuits in traditional processing tasks, analog technology will certainly play a dominant role in carrying out real-time perceptive tasks. Indeed, these tasks do not need the precise computation achievable by digital processing. They require the parallel and collective processing of a massive flow of data, for which low-precision analog circuits are more efficient with respect to power consumption and chip area.

Paper contributions to the 1996 MicroNeuro conference, from which we selected the articles for this issue of IEEE Micro, were balanced between analog and digital implementations. However, MicroNeuro confirmed the trend toward analog technology by devoting two full sessions to analog VLSI for vision and for the implementation of new processing schemes inspired by a closer examination of biological solutions. (See the accompanying box for a more thorough description of MicroNeuro 96.)

Selecting a few MicroNeuro papers for adaptation for Micro was not an easy task. To represent the conference profile, we have chosen one article on a digital implementation, four on analog implementations, and one on a very original technical application.

The L-Neuro 2.3 digital architecture developed by M. Duranton of LEP in France is a vector processor composed of an array of 12 DSPs, well adapted to image processing. The operative units are controlled by 286-bit-wide (micro)instructions issued at a 60-MHz frequency. To develop the software, Duranton’s group used VML, a virtual machine language defined at UCLA London as part of the ESPRIT Galaxie project.

In the next article, A. Kramer analyzes the architecture of neural networks—based on summing the output of local operators (synapses) organized in 2D arrays. He shows that this architecture is perfectly suited to exploit the very high efficiency of analog computation when an overall precision of 5 to 6 bits is acceptable. Kramer describes three VLSI chips using different local operators working in different modes: One chip obtains the Manhattan distance in charge mode by exploiting device physics; the second computes the dot product in conductance mode; and the third computes the Euclidean distance in current mode. Each chip has its respective merits with respect to power consumption, speed, chip area, and application domain.

The retinomorphic system K. Boahen describes further demonstrates the high efficiency of analog processing. Far from being just a camera, the retina is an extension of the brain that provides acquisition, conditioning, spatiotemporal filtering, and optimum coding for further communication and processing of the image projected on it. Boahen uses a dense array of analog cells to implement similar features on silicon chips. We expect this silicon retina to drastically enhance the performance of future artificial vision systems, in which it will function as a front end.

The article by G. Indiveri, J. Kramer, and C. Koch shows how to achieve robust operation—despite the very limited precision of low-power, small analog cells—by using collective processing in a cell array. The authors describe three different analog VLSI systems that rely on integrative features of the optical-flow field evaluated by arrays of compact analog velocity sensors. One system obtains the focus of expansion by selecting the steepest and closest zero crossing of velocity. The second evaluates time to contact through summing the activities of velocity sensors arranged on a circle. The third uses motion discontinuity detection to control the local amount of smoothing and thus segment images into different objects.

Analog computation can operate in an essentially passive manner through the dis-
MicroNeuro 96

MicroNeuro, the International Conference on Microelectronics for Neural Networks, has emerged as the only international forum specifically devoted to all aspects of implementing artificial neural networks and fuzzy systems. In this, it differs from other conferences on neural networks, which usually relegate hardware implementations to hidden corners of the program. MicroNeuro complements the well-established circuit conferences by addressing the particular requirements of neural and fuzzy systems and by exploiting the related new field of possible solutions. In addition, it emphasizes working devices rather than design proposals. Most of the devices introduced are still experimental, but others are already applicable in the real world.

Like previous conferences, the program of the fifth MicroNeuro, which convened in Lausanne on the shore of Lake Geneva last February, centered on silicon VLSI implementations. A balanced number of contributions outlined digital and analog approaches. Intended applications included pattern, character, and speech recognition; intelligent control; robot navigation; classification; and general problem solving.

MicroNeuro's paper sessions addressed analog VLSI for vision and for the implementation of new processing schemes inspired by a closer examination of biological solutions; further analog implementations of various architecture types and image-processing systems; pulse stream networks, in which pulse duration or frequency represents analog information; and digital implementations including chip architectures and full systems. A special session offered an overview of the various methods that can simplify hardware implementations and the possible use of technologies beyond standard silicon VLSI. Finally, there were 20 posters, each accompanied by a three-minute oral presentation and a discussion period.


Due to its specificity and success, in the future MicroNeuro will be organized alternately in the US and in Europe; the next planned locations are Dresden, Denver, and Granada.

We wish you good reading of this issue, and hope that it will give you some feeling of the need for increased neural network processing power, and how this can be implemented.

Eric A. Vittoz is senior vice president heading the Bio-Inspired System Section of the Swiss Center for Electronics and Microtechnology (CSEM) in Neuchâtel. He also lectures and supervises student projects in analog circuit design at the Swiss Federal Institute of Technology in Lausanne (EPFL), where he is a professor. His field of research interest is the design of low-power analog CMOS circuits, with emphasis on their application to analog VLSI for perceptive computation.

Vittoz received MS and PhD degrees in electrical engineering from EPFL and is a fellow of the IEEE. He has published more than 100 articles and holds 25 patents.

Jean-Daniel Nicoud is a professor at EPFL and director of LAMI, the university's Microprocessor and Interface Lab. He has actively pursued microprocessor-related research, designing many microprocessor-based systems. His interests and those of his research group include microcomputers, peripherals, autonomous robotic systems, and neural networks. He is now very concerned with the application of robots to searches for anti-personnel mines and the development of adequate sensors for this purpose. World Wide Web access to a description of his lab is http://diwww.epfl.ch/lami/.

Nicoud received an MS in physics and a PhD in electrical engineering from EPFL. He has authored four books and numerous articles and is a member of the IEEE.

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