Awards

The *first recipient* of the IEEE GUSTAV ROBERT KIRCHHOFF AWARD:

Professor Leon O. Chua

This new technical field award of the IEEE is given "For outstanding contributions to the fundamentals of any aspect of electronic circuits and systems that has a long term significance or impact." The first recipient, made public in December 2004, is Professor Leon O. Chua, "For seminal contributions to the foundation of *nonlinear circuit theory,* and for inventing *Chua's Circuit* and *Cellular Neural Networks,* each spawning a new research area.

"Chua's Global Invisible College"

In 1996, for the occasion of the 60th Birthday of Leon Chua, the following lines were written by Ildikó and Árpád Csurgay: "... we are very much obliged to him for his *brilliant paradigms*... We express our thanks to him for establishing *Chua's Global Invisible College* around his center of excellence in Berkeley, ... "

Indeed, many of us, all over the world belong to his Invisible College. A College of excellence in Nonlinear Science and his Nonlinear Electronics Laboratory (NOEL) in Berkeley.

Brilliant Paradigms

Nonlinear circuit theory, Chua's Circuit, and the Cellular Neural/nonlinear Network (CNN) are three cornerstones we owe to Professor Chua.

As to *nonlinear-circuit theory*, he is widely recognized as the foremost pioneer in this area. Many concepts presented in his 949-page book on "Introduction to Nonlinear Network Theory" have found important applications, including the design of cellular neural networks where the nonlinear driving-point plot technique developed in this book is indispensable. His axiomatic definition of nonlinear circuit elements represents a paradigm shift in circuit theory, which led to a unified theory of linear and nonlinear circuits based only on *Kirchhoff laws* and *element laws*. Chua's axiomatic approach has clarified and resolved several paradoxes of a foundational nature. Among many fundamental circuit theoretic results based on controlled sources discovered by Chua, he had proved the *fundamental theorem* that *every nonlinear* device can be modeled using only *linear* resistors, capacitors, controlled sources, and 2-terminal nonlinear resistors. This is one of the few truly deep and *foundationa*l results of circuit theory. Another fundamental contribution is the qualitative theory of dynamic circuits presented in 3 seminal papers which have become standard references and foundations of numerous subsequent publications in nonlinear dynamics.

Among other fundamental results, it shows that there are fundamental limits of performance among different classes of nonlinear circuits. In particular, Chua proved that no information processing circuits such as flip-flops, oscillators, memories, etc. can be built from locally-passive nonlinear elements. His theory of *local activity* has become the foundation for designing complex dynamic circuits, including neural networks. Moreover, Chua's theory of local activity has provided the fundamental analytical tool for studying *complexity theory*, currently a very active multidisciplinary area cutting across physics, chemistry, biology, economics, etc. In all of these cases, Chua's *nonlinear circuit synthesis technique* is used to map the complexity problem into an equivalent nonlinear circuit model where many deep analytical results developed by Chua can be applied.

Dr. Chua is responsible for introducing *chaos theory* and *nonlinear dynamics* to Electrical Engineering by inventing *Chua's circuit* and proving it to have strange attractors. Along with the Lorenz equation, Chua's circuit is the example of choice in numerous publications on *chaos* where more than 800 publications have cited Chua's circuit as of 2003. Chua's circuit is also the prototype circuit used by most researchers designing secure communication systems based on chaos.

Another contribution of Professor Chua which has made major impacts is his invention the *Cellular Neural*

Network (CNN). Based on this, as the core "instruction," with T. Roska, they invented the *CNN Universal Machine* architecture. Among all neural network architectures published to date, CNN universal machine is the only one that has been successfully implemented into a practical fully-programmable chip capable of solving ultra high-speed pattern recognition and image processing problems. In addition, the CNN Universal Machine is a stored programmable cellular wave computer architecture, a universal machine on flows (developed later). For many mission critical applications, the CNN universal chip has outperformed conventional supercomputers, and has become the enabling technology of choice. As a further testimony of the impact of the CNN universal machine based chip (namely, the ACE 16 k visual microprocessor chip developed in Seville) as an enabling technology, a commercially available 3-D camera computer called the Bi-i has been developed. The Bi-i was awarded the "First Prize and the Product of the Year" title at the most prestigious machine vision fair in Europe, the Vision 2003, in Stuttgart, Germany. In addition, the potentials of the CNN universal chip as an ultra-high speed vision computer has attracted many active research groups worldwide, who interacted actively through special sessions at ISCAS and ECCTD, special issues in journals, and at the bi-annual international workshop devoted exclusively to CNN applications (CNNA).

Lecturing and Mentoring

Leon Chua has given many keynote lectures at ISCAS, ECCTD, CNNA, NOLTA, etc. His works and lectures have inspired and stimulated a new generation of enthusiastic young researchers on nonlinear dynamics and information theory.

Dr. Chua has received the prestigious IEEE Neural Networks Pioneer Award from the Computational Intelligence Society in 2000 in recognition of his impact in neural networks. He has received 7 patents and 9 honorary doctorates. He is a recipient of the top 15 cited authors in Engineering award in 2002, chosen from the Current Contents (ISI) database of all cited papers in engineering disciplines in the citation index over a 10 year period from 1991 to October 2001. He was elected a foreign member of the European Academy of Sciences in 1997.

For the record, let me also list some IEEE and professional activities, as well as major honors and awards of Dr. Chua:

- Editor, IEEE Transactions of Circuits and System, 1975–1977.
- President, IEEE Circuits and Systems Society, 1977–1978.
- Chairman, IEEE CAS Fellow Committee, 1992–2000.
- Editor, International Journal of Bifurcation and Chaos, 1990-present.
- Editor, Book Series on Nonlinear Science, World Scientific Publishing Company, 1990.
- IEEE Neural Networks Pioneer Award, 2000.
- IEEE Third Millenium Medal, 2000.
- IEEE Circuits and Systems Society Golden Jubilee Medal, 2000.
- IEEE Circuits and Systems Society MAC Van Valkenburg Award, 1995 and 1998.
- IEEE CAS Technical Achievement Award, 1993.
- IEEE Fellow, 1974.
- IEEE W. R. G. Baker Prize, 1973.
- IEEE Browder J. Thompson Prize, 1973.
- IEEE Frederick Emmons Terman Award, 1974.
- Alexander von Humboldt Senior Scientist Award, 1982.

All in all, I do think, the first awardee of the IEEE Kirchhoff Award is a Scientist-Engineer for all seasons.

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