SIMULATION OPTIMIZATION SYSTEMS
Research Laboratory

ONE-DAY WORKSHOP

ON

NEXT GENERATION OPTIMIZATION METHODOLOGIES FOR WIRELESS AND MICROWAVE CIRCUIT DESIGN

Monday, June 28, 1999
McMaster University, Hamilton, ON
Room JHE A114
08:30-18:00

Organized by
J.W. Bandler and Q.J. Zhang

SPECIAL GUESTS
Peter Leach
Radek Biernacki
Dan Swanson

Refreshments and lunch will be provided

To register contact John Bandler
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NEXT GENERATION OPTIMIZATION METHODOLOGIES FOR WIRELESS AND MICROWAVE CIRCUIT DESIGN

J.W. Bandler and Q.J. Zhang

Abstract

We present new research results in optimization technology for RF, wireless and microwave circuit design, integrating electromagnetic (EM) simulations. A tutorial review as well as new research directions and algorithms in Aggressive Space Mapping (ASM) optimization are presented. Applications exploit commercial EM simulators such as Sonnet and HP HFSS: waveguide structures, microstrip filters, patch antennas, circuit decomposition techniques, mixed EM/circuit structures and signal integrity optimization of VLSI packages and interconnects.

We focus on two exciting device modeling concepts: modeling through Artificial Neural Network (ANN) technology and modeling through Space Mapping (SM) technology. These concepts have recently been merged into a variety of Space Mapping based neuromodeling strategies.

We discuss the neural network paradigm for high-frequency device modeling and circuit design. We address the development process for RF/microwave neural models. We review new directions in model development for RF/microwave components and devices utilizing ANNs and SM. Various ANN and SM based ANN models can be developed through NeuroModeler, the world's first software for neural based device modeling and circuit design. The gap between neural modeling and circuit simulation and optimization is also addressed. The gap may be bridged by plugging trained neural models into circuit simulators such as HSpice and HP ADS through NeuroSpice, a macro-processor for HSpice, and NeuroADS, a plug-in module for HP ADS. Examples include EM simulations, filters, transmission-line networks, transistor device models, etc.

WORKSHOP PROGRAM

08:30	Coffee
08:45	J.W. Bandler (McMaster and Bandler Corporation), "Opening remarks"
08:50	P. Leach (President and CEO, CITO), "Welcome address"

PART I OPTIMIZATION TECHNIQUES

09:00	J.W. Bandler, "Optimization technology for RF, wireless and microwave circuit design, integrating electromagnetic (EM) simulations"
09:40	J. Rayas-Sánchez (McMaster), "Space mapping optimization for engineering design: a tutorial presentation"
10:00	M.H. Bakr (McMaster), "New directions in EM optimization using space mapping technology"
10:30	Coffee break
10:45	J.W. Bandler, M.H. Bakr and N. Georgieva (McMaster), "Applications exploiting commercial EM simulators including waveguide structures, microstrip filters and patch antennas"
11:30	R.M. Biernacki (Invited speaker, HP EEsof), "New developments in HP HFSS and HP Momentum optimization"
12:00	Lunch
13:00	D.G. Swanson, Jr. (Invited speaker, Bartley RF Systems), "CAD of microwave components using EM field solvers"

PART II DEVICE MODELING

13:30	Q.J. Zhang (Carleton), "Overview of neural network paradigm for high-frequency modeling and design"
14:00	F. Wang (Carleton), "Methodologies for developing RF/microwave neural models"
14:30	J. Rayas-Sánchez (McMaster), "New directions in model development for RF/microwave components and devices utilizing neural networks and space mapping"
15:00	Q.J. Zhang, "Bridging the gap between neural modeling and circuit simulation and optimization"
15:30	Coffee

PART III NeuroModeler DEMONSTRATION

15:45	Q.J. Zhang, "Introduction to NeuroModeler, NeuroADS and NeuroSpice"
16:00	F. Wang (Carleton), "NeuroModeler demonstration"
16:40	F. Wang and S. Wang (Carleton), "NeuroADS and NeuroSpice demonstration"
17:00	Audience interaction for NeuroModeler, NeuroADS and NeuroSpice

PART IV DISCUSSION PERIOD

17:30	General Discussion
18:00	Closing remarks by J.W. Bandler

NeuroModeler 1.2

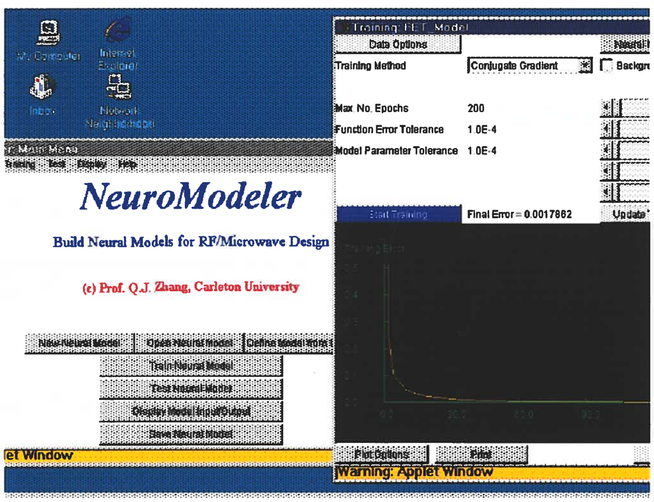
Build Neural Models for RF/microwave Design

ABSTRACT:

Artificial Neural Networks are emerging as a powerful technology for RF and microwave characterization, modeling, and design. NeuroModeler is the first software in the industry that embraces this technology with complete RF and microwave orientation. It features fully integrated RF and microwave knowledge based neural network architectures. It helps you to immediately start developing neural models for RF/Microwave components and circuits and helps to provide neural models for your simulators.

OUTLINE:

Recently, artificial neural networks are introduced to the microwave community, opening the door for an unconventional approach to microwave computer-aided design. Here is a brief outline of the what's, why's, when's and how's, intended to give the RF/microwave engineers the shortest cut to gain from this new technology.



Training Window of a FET Model, with main menu on background

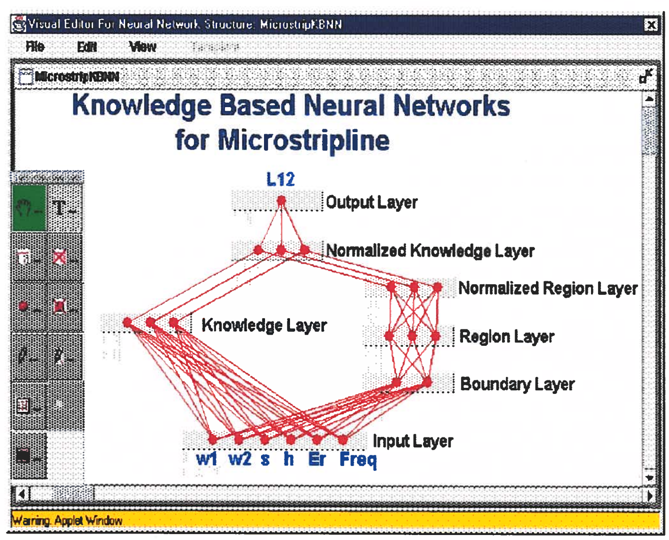
What: Artificial Neural Networks are information processing systems inspired by the ability of human brain to learn from observations and to generalize by abstraction. The fact that neural networks can learn totally different things led to their use in diverse fields such as pattern recognition, speech processing, control, medical applications and more. Recently, microwave researchers developed techniques in which neural networks are trained from microwave data, and then used to enhance microwave design.

Why: The microwave industry's drive for manufacturability-driven design and time-to-market, demands efficient and reliable CAD tools. However, manufacturability-driven design, e.g., statistical design with accurate models such as EM models are time-consuming. Simpler models are fast but are often under limited assumptions or mismatch may occur between computer solutions and hardware measurements. Accuracy, speed and flexibility have been for most of the time contradictory, until recently when neural models for microwave components are introduced. Neural models can be much faster than original detailed models, more accurate and flexible than empirical models, and easier to develop when a new device/new technology is introduced.

When: Neural-based modeling is a generic technique, and shines especially in challenging microwave design situations where conventional techniques balk. Examples are, EM–level modeling but not the expensive EM computations, modeling new components when component formulae are not available, supply user-defined components to simulators when simulator does not easily support user-plugs, etc.

How: NeuroModeler is a RF/microwave oriented software tool, to help you to quickly develop neural models for active and passive components; at both device and circuit-levels; and for linear or nonlinear simulations. The software is written for typical RF/Microwave designers who are not neural network experts but would like to immediately get started with this new technology.

What's Special: NeuroModeler is the first and only software that allows your RF/microwave knowledge to be integrated with neural network learning. You can supply your knowledge through symbolic expressions, or through a circuit netlist with our build-in circuit simulator, or through your own simulator which NeuroModeler can drive, or through a C program source code to be linked with NeuroModeler.



A Microstripline Neural Model defined by Visual Editor

TECHNICAL SUMMARY:

Neural model contains a set of neurons and connections between neurons. Each neuron has an activation function processing the incoming information from other neurons. Take a neural model for microwave transmission line as an example, the transmission line geometrical parameters (say x) will be model inputs sent to some neurons called input neurons. After internal processing of all neurons, the neural model will produce electrical quantities (say y) of the transmission line at some neurons called output neurons. In model development stage, samples of x-y data are generated (e.g., from EM simulation or measurement). The model is then trained to learn from the data. Training is similar to an optimization process where internal parameters of the neural model are adjusted such that modeled solution best fits training data. A trained neural model can then be used online during microwave design stage providing fast model evaluation replacing original slow EM simulators. Since neural model is trained directly from data, the model can be developed even if original problem formulae do not exist.

Highlights of Product Features

- **Model Creation and Editing:** Use NeuroModeler to easily create a neural network model. The built-in default automatically defines a model structure and number of neurons for you. You can choose from a variety of templates or define customer structures of neural models. Attractive visual editor let you define model structures graphically.
- **Data Processing:** Here you dictate what the neural network should learn from your data. NeuroModeler automatically performs basic data preprocessing for you. NeuroModeler can even help you to generate data using its Simulation Driver feature.
- **Training:** NeuroModeler automatically checks your data and suggests a training technique. The program also has an Auto-Pilot training method, which intelligently adjusts the neural model size and training methods to achieve the required model accuracy. User can modify any training defaults and suggestions.
- **Test:** The performance of neural model can be verified using an independent set of data, either with a simple error criteria, or by a variety of detailed plots. You can also evaluate interpolation and extrapolation capabilities of your model.
- **Export:** You and your work are not locked to NeuroModeler format. You can export the trained neural model to your own user-environment, be it a spreadsheet, or a computer-source code, or a simulator.

Neural Network Structures

- Multilayer Perceptrons, Radial Basis Functions, Wavelet Networks, Knowledge-Based Neural Nets, Space Mapped Neural Nets, Prior Knowledge Input Networks, Hierarchical Neural Nets, User-defined Structures.

Neuron Functions

- Sigmoid, arctangent, hyperbolic tangent, Gaussian, linear, quadratic, polynomial, rational, log, exponential, normalized, multi-sigmoid, time or frequency domain approximations, inductance/capacitance functions, symbolic expressions, internal or external simulators, user-defined functions.

Training Methods

- Adaptive Back-propagation, Sparse optimization, Simplex, Conjugate Gradient, Quasi-Newton, Huber-Quasi-Newton, Auto-Pilot, Genetic Algorithm, Simulated Annealing.

RELEVANCE TO THE RF/MICROWAVE COMMUNITY:

One of the keys to achieve manufacturability-driven design and time-to-market is to use efficient and reliable CAD tools. Components, circuits and systems must be represented by models, as a pre-requisite of any computer-aided design. The availability, accuracy, flexibility of models, and the speed of model computation affect largely the effectiveness at all stages of computer-aided design.

NeuroModeler: Build and use neural network models for RF and microwave modeling, simulation and optimization, an unconventional technology, with surprising answers to some of the toughest problems in RF and microwave computer-aided engineering. Get speed AND accuracy AND flexibility of neural model. Pursue re-usability of the modeling technology for today's AND tomorrow's devices and circuits.

Use NeuroModeler to finish your design sooner than otherwise, to let you focus on immediately getting a model rather than learning component theory, to let you start working with any model you need rather than having to wait and beg for model availability from tools/vendors/manufacturers.

Use NeuroModeler to enhance the "bottom line" (i.e., models) of all CAD tools to help reducing microwave design cycle and time-to-market.

Developed by one of the world's leaders in this new technology, NeuroModeler is the first and a unique software tool of its kind for RF and microwave designers. With NeuroModeler, you can uncover the myth, and bypass the hardships that a non-neural net expert typically encounters when attempting this new technology. Neural Model Technology has never been so reachable, and so connected to RF/microwave designers until today.

For more information contact:
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