ASSOCIATION OF
ENERGY ENGINEERS

Bay Area Chapter

NEWSLETTER

July 1999

Dinner Meeting Information Tuesday, July 27th

Energy Efficiency Opportunities in Manufacturing Facilities, an Untapped Market

Our speaker will be Ahmad R. Ganji, Ph.D., P.E. a principal of Berkeley Applied Science & Engineering, Inc. (BASE), an engineering consulting firm in San Francisco. BASE consults with manufacturing plants and utilities in industrial energy conservation and waste minimization. Dr. Ganji is also a professor of Mechanical Engineering at San Francisco State University. Since 1992 he has been the director of Industrial Assessment Center (IAC). IAC is a US Department of Energy-sponsored project dedicated to industrial energy conservation, waste minimization, and productivity improvement for small to medium sized manufacturing facilities.

See the enclosed flyer for more info...

From the Editor

Artificial Neural Networks

Why you might want to give them a serious look

by Jim Kelsey

I got some good news and some bad news this week. The bad news was that a research proposal that I had submitted to the CEC's Energy Innovations Small Grant Program was rejected. I have to take the blame for that one - they had requested proposals for original research and my "innovative idea" turns out to have a prior claim. So in the mail this week, instead of a godsend grant to develop what I think is a really elegant way to control large energy-using systems, I get a very polite but slightly grumpy letter from the state saying thank you very much but you're about 5 years too late. SAIC and SDG&E have beaten you to it.

whoops...

Well it wouldn't have been so bad if I hadn't already shot my mouth off to anybody that would listen about how great an idea I thought this was. I found this news extremely disappointing - not only because I wouldn't get to spend six months developing and testing a really interesting way to control thermal storage systems, but also because I was suddenly way out of the running for the "Energy Engineer of the Millennium" title.

Oh well. Better luck next millennium.

So what's the big idea?

Artificial neural networks (ANNs) have been utilized in an increasing number of industries as a tool for controlling complex processes and predicting the outcomes of complex physical and economic systems. Our idea was to use ANNs to optimize building controls to respond to real time pricing. Specifically, I had proposed a thermal energy storage system as a test case for determining the concept's viability. But because ANNs are adaptable to all types of input parameters, their use could be extended to optimization of other mechanical systems. I could see immediate applications for optimal condenser water temperature in chilled water plants or floating head pressure control in refrigeration systems.

So what is an Artificial Neural Network?

An artificial neural network is a mathematical model inspired by the way the interconnected, parallel structure of the brain processes information. ANNs have been applied successfully in research and commercial applications as diverse as robotic control of industrial processes, voice recognition software, and market forecasting tools. ANNs have only recently been used to control thermal systems in response to energy pricing signals (the SAIC/SDG&E project is the only instance that I know of).

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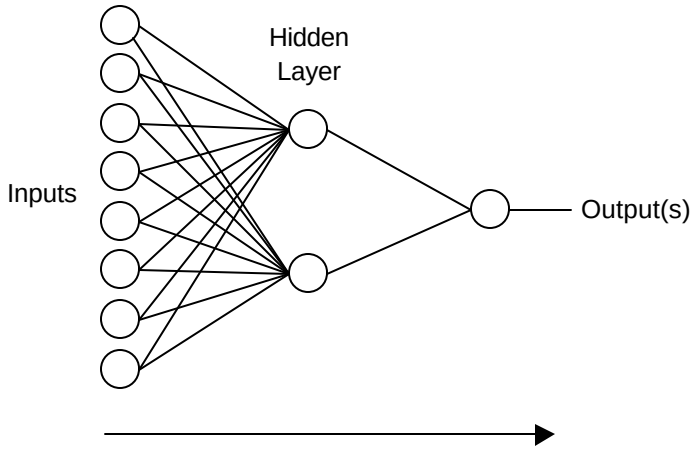
From the Editor (Cont.)

An artificial neural network develops a set of outputs based on a system of input conditions - similar to a standard regression model except that ANNs respond better to non-linear systems. The basic structure is shown in the diagram below.



Each of the circles in the figure represents a network unit or neuron. When a new input signal is received, each unit sends a different output signal to each unit that it is connected to on the right. The connecting lines in the diagram represent this communication. The input signals are weighted differently between each pair of network units. The second column of two circles is called a hidden layer. A neural network may have one or more hidden layers. It takes input signals (from the left), multiplies them by a weight, and sends an output signal to the output layer. The output layer takes a weighted sum from the hidden layer and produces a final output. The outputs can be a single value as in this case, or there can be multiple output neurons.

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AEE Bay Area Chapter

AEE Bay Area Chapter serves as a unique forum for the discussion of energy issues and concerns. AEE Bay Area Chapter provides common professional meeting ground for facility managers, design and specifying engineers, utility and vendor representatives and energy researchers to participate in vigorous peer-to-peer dialogue, learning and group discussion.

AEE Bay Area Chapter strives to provide quality professional development opportunities which build knowledge and skills through meetings, seminars and publications. Emphasis is placed on:

- Assessing the applicability of emerging technologies, and
- Improving the performance and reliability of current technologies.

Meetings are held on the fourth Tuesday of the month. All interested persons are welcome to attend, participate and join the Chapter. If you are interested in joining the AEE Bay Area Chapter, contact Ken Moore at (415) 460-0460.

A neural network "learns" through a process called training. A set of input variables is supplied to the network and the corresponding output is compared to a known output (the value we are trying to model). Initially the weighting factors are assigned randomly between each node. These factors are then perturbed successively and statistical methods are used to adjust the weighting factors so that the difference between the output of the network and output of the modeled system (i.e., the error) is minimized. After the training of the network is complete, the ANN can be used to model the system without further supervision.

Why are ANNs a promising technology for optimization of energy-using systems?

ANNs are unique in that, without any real understanding of the underlying system, they can accurately predict the performance of complex physical and economic systems. This is a tremendous benefit in the application to energy using systems because of the nature of the complex interactions among mechanical equipment. For example, developing a computer simulation that reasonably predicts the energy use of a building in response to varying weather conditions is difficult and time-consuming and can cost tens of thousands of dollars for an individual facility. Even when completed, the predictive ability of these models is typically not better than ± 10%. This accuracy decreases over time as the operation of the building and its mechanical systems stray from the conditions assumed in the model. An ANN has the potential to be more accurate, has the ability to improve its performance over time, will take much less engineering time to develop (at least once we have a few in place), and takes less computing power to run. Furthermore, the longer an ANN can train on the input data, the better its predictive abilities will be.

Once you have a simple model for predicting the response of your building or plant, you are a step away from optimizing the operation. For example, let's say that I install an ANN on my building & have it learn how the total plant energy (at the meter) varies over time with a variety of condensing water temperatures, loads, and weather. Once the model has been trained, I can then run through different control scenarios very quickly. Marry this with an input for RTP rates and you have a method for determining the best condensing water temperature for the plant on an hourly basis based on the hourly energy price, the weather forecast, and the historical performance of the building and mechanical equipment. All of this can take place very quickly and could be automated so that you don't have to fiddle with it on a daily basis.

The Good News

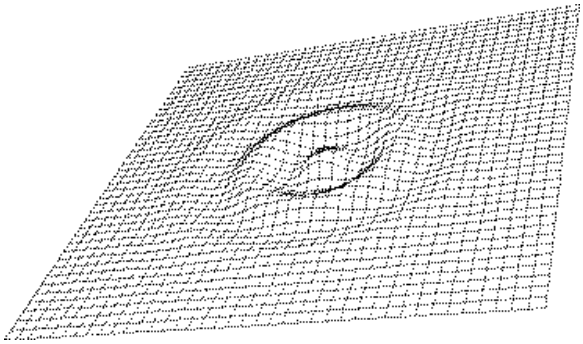
Anyway, before you judge my idea as too sci-fi-pie-in-the-sky, let me tell you the good news. The team that beat us to the idea, won a Smithsonian award for innovation. Suddenly I don't feel so bad. And the building that they installed the software in saved 6% on their energy bills. Not bad for a controls retrofit with little or no new equipment cost. This is a pretty promising start for a technology that is far from fully developed.

One more note. Open architecture has been pivotal to the rapid development of powerful and useful applications on the internet. Open architecture for building energy systems will likely do the same. I suspect that ANNs will work well in conjunction with each other, if they can communicate. Adopting a common protocol (BACNET anyone?) among building systems will provide the foundation for the lowest overall energy consumption

So what do you think? Personally I think that the time has come to put ANNs to work for us in buildings. But I would like to hear what you think. Please direct letter's to the editor at editor@aee-sf.org. Or if you prefer to let the AEE membership and world in general know directly, publish you thoughts directly on the web in our discussion forum / guestbook.

Respectfully submitted, Jim Kelsey.

For more info on the topic with links to related web sites, see the online version of this article at www.aee-sf.org.



Career Opportunity

EMCOR Energy Services, a division of EMCOR Group, Inc. (www.emcorgroup.com), the world's largest mechanical/electrical contractor, is rapidly growing. We are seeking design and analysis engineers at our San Francisco based subsidiary, Newcomb Anderson Associates, and in our Boston and Philadelphia offices. Performance contracting or practical energy project experience desired. For more information about our company and outstanding employment opportunities, please visit www.newcombanderson.com or fax inquiries to 415/434-2321, attn: Recruiting. Full benefits, excellent work environment, equal opportunity employer.

How can you get your message to all the energy geeks in the Bay Area?

Put it here! Target your message to the local energy engineering crowd. We welcome submissions such as employment opportunities, energy-related events, or any information of interest to members of the Bay Area AEE Chapter.

Email your brief announcement to: **aee@kw-energy.com**

Do you know someone who might be interested in joining AEE Bay Area Chapter?

The benefits of joining include:

- Participating in exciting and informative programs
- Receiving a monthly newsletter containing information on meetings, events, and job openings
- Communicating with other energy professionals

For membership application:
Contact Ken Moore
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Meetings are held on the fourth Tuesday of each month. All interested persons are welcome to attend, participate and join.

AEE ASSOCIATION OF ENERGY ENGINEERS Bay Area Chapter

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