Neural-net neighbors learn from each other

In their quest to understand how the brain works, Canadian computer scientists have developed a neural network that teaches itself to judge depth and recognize objects.

Neural networks are computer models that mimic information processing done by groups of brain cells. Since the mid-1980s, scientists have used a technique called back propagation to train neural networks to recognize visual patterns or everyday speech. This approach requires that the neural network have an external "teacher" that knows the right answer.

Suzanna Becker and Geoffrey E. Hinton of the Canadian Institute for Advanced Research at the University of Toronto have now created a network whose elements depend on each other for the right answer. In the Jan. 9 NATURE, they describe their mathematical procedure for self-taught neural networks.

The algorithm they use represents one of several approaches in the emerging field of "unsupervised learning" that could lead to smarter neural networks. "It can make training [these networks] easier and less expensive if you can do at least part of the training in an unsupervised way," says Ralph Linsker, a computational neuroscientist with the IBM Thomas J. Watson Research Center in Yorktown Heights, N.Y.

With back propagation, a neural network typically learns to recognize images or words by comparing its answer with an answer programmed into the computer. Then the network changes the way in which it processes its data until it finally gets the same result as its teacher.

"But a lot of the learning people do doesn't work like that," Hinton says.

So the Toronto team based its algorithm on the assumption that when neighboring elements sense the same thing, they should come up with the same answer about what that thing is. The researchers set up their network so that elements near one another see adjacent, but not overlapping, parts of an image.

At first, neighboring elements get very different answers, but with each new attempt they change the way they process incoming information, until finally their answers match up. "Rather than have an external teacher, you can think of the network as a little community of modules in which the modules learn from each other," Hinton explains.

Becker and Hinton demonstrated this technique with a computer program that simulates a neural network involved in vision. They programmed the network to "see" a stereo image and to judge the depth of dots on a curved surface. The network consisted of 10 modules, each representing a group of brain cells.

During a simulation, a module acts as if it has received information about dot location from a small patch of nerve cells in each eye. Neighboring patches should perceive the dots as being at almost the same depth; therefore, the corresponding modules should come up with the same answer about how far away the dots are. Becker and Hinton provided the network with 1,000 examples from which it learned to judge depth.

In addition, Hinton and graduate student Richard S. Zemel have used self-teaching to train the neural-network modules to predict an object's size, position and orientation after "seeing" just one end of the object. In these simulations, two modules see opposite ends of the object and then compare and modify their predictions until they can recognize the object no matter what its size or location in space.

Self-teaching takes a long time, sometimes longer than learning through back propagation. But the Toronto team hopes to use the new approach for training complex neural networks. By treating the many processing layers as a hierarchy, "the system can learn a layer at a time," Hinton says. *– E. Pennisi*

Planes: Larger role in global warming?

Nitrogen oxides (NO_x) constitute a family of combustion gases that can foster ozone, both in urban smog and in the rarefied atmosphere high above Earth's surface. Through their production of ozone — a greenhouse gas when trapped within the upper troposphere — they may also contribute to global warming. A controversial analysis now suggests that the NO_x emitted by cruising aircraft pose a small but growing greenhouse threat.

Since the 1970s, chemists have recognized that high-flying aircraft should pose a more potent warming threat, per gram of NO_x emitted, than cars and other ground-level sources. Why? Adding NO_x to regions with low ambient levels of this pollutant, such as the upper reaches of the troposphere (8 or more kilometers above Earth's surface), drives far more ozone production than would an equal addition into a nitrogen-oxide-rich environment, such as downtown Los Angeles, explains Colin Johnson of the Atomic Energy Authority's Harwell Laboratory in Didcot, England. Moreover, he says, "the greenhouse warming per molecule of ozone is greater [at higher levels] in the atmosphere."

But until recently, no one had quantified both of these factors in connection with aircraft, Johnson says. "Because we had written a new model of the atmosphere, we thought it would be an ideal opportunity to analyze the question," he told SCIENCE NEWS.

In the Jan. 2 NATURE, Johnson and his colleagues conclude that aircraft may contribute roughly as much to global warming as surface NO_x, even though they produce only about 3 percent of combustion-generated NO_x.

Together, all sources of nitrogen oxides will contribute only about 3.5 percent as much to global warming as will carbon dioxide over the next century, they estimate. However, if air traffic maintains its present rate of growth, "we've got to keep a careful eye on [NO_x emissions]," Johnson warns.

Others remain skeptical. Michael J. Prather, an atmospheric scientist at NASA's Goddard Institute for Space Studies in New York City, questions the team's reliance on a two-dimensional (latitude and altitude) model of the global atmosphere. Such models, he says, are "inadequate" to predict the dispersion of aircraft contrails and pollutant plumes, since they make no provision for convective mixing of short-lived gases such as NO_x.

Johnson agrees that an evaluation with three-dimensional models is needed. Indeed, he says, "that's the next phase of our study." *– J. Raloff*

CF gene therapy on horizon

In a large-scale study, scientists have inserted healthy copies of the human gene associated with cystic fibrosis into rodent lung cells. Experimental gene therapy for humans might start as early as a year from now, says Ronald G. Crystal of the National Heart, Lung, and Blood Institute in Bethesda, Md.

In 1989, a U.S.-Canadian team identified the cystic fibrosis transmembrane conductance regulator (CFTR) gene, which, when faulty, leads to cystic fibrosis (SN: 9/2/89, p.149). Last spring, Crystal reported using an altered cold virus to insert a healthy human CFTR gene into the lung cells of three cotton rats (SN: 3/2/91, p.132). The virus can penetrate airway cells of the cotton rat, a cross between a rat and a hamster.

Crystal's team reports in the Jan. 10 CELL testing the technique on hundreds of cotton rats and successfully inserting the healthy human CFTR gene into epithelial cells lining the animals' lungs. Once inside the epithelial cells, the human gene turned on, producing its protein product for at least two weeks, Crystal says.

"This is a direct strategy that has the potential of curing the disease," he told SCIENCE NEWS. □