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Artificial neural networks aid land-cover study

Artificial neural networks may sound like something straight out of "Star Trek: The Next Generation," at work inside the android "Data" perhaps, but not really practical yet. However, not only are they real, they've been put to use by University of Nebraska-Lincoln researchers in a land-cover classification study.

Wenli Yang and Luoheng Han, graduate students with the Center for Advanced Land Management Information Technologies (CALMIT), have explored the possibility of using artificial neural networks to interpret land-cover data, and like what they came up with. Yang presented their study at the annual meeting of the Nebraska Academy of Sciences April 16 at Nebraska Wesleyan University in Lincoln. CALMIT is a unit of the Conservation and Survey Division.

In a preliminary study, their neural network interpreted land-cover images with 99.58 percent accuracy, a figure comparable with the accuracy of the traditional statistical method. Put simply, an "artificial neural network" is a computer program that interprets information in a manner similar to that of the human brain. The network consists of "layers" of software nodes, each of which is analogous to a function of the brain.

The bottom layer is the sensing layer, the "eyes" of the computer. This is where information (in this case, aerial photographs) enters the program, just as visual data enters our brains through our complex optical system.

Next are several "hidden" layers that actually process the information. All these layers are interconnnected. The connections among the layers are the neural networks's long-term memory layer, which stores images that the program has previously been exposed to, like our memory stores images of

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Remote-sensing detection of atrazine shows promise

Natural resource managers and others concerned about atrazine in water supplies may have a new tool for detecting contamination, thanks to the efforts of a University of Nebraska-Lincoln research team.

Consisting of graduate students Rolland N. Fraser, Luoheng Han and Doug Goodin, all with the UNL Center for Advanced Land Management Information Technologies (CALMIT), as well as researchers from Creighton University and the University of Kansas, the team has successfully used remote sensing to detect atrazine concentrations in water in a preliminary study. CALMIT is a unit of the Conservation and Survey Divison. Fraser presented their study at the annual meeting of the Nebraska Academy of Sciences April 16 at Nebraska Wesleyan University in Lincoln.

In a very controlled experiment, the team was able to detect atrazine in concentrations as low as 20 micrograms per liter, or parts per billion. The maximum contaminant level established by the U.S. Environmental Protection Agency for atrazine in drinking water is 3 parts per billion. Fraser said the 20-microgram level was fairly normal for some lakes and rivers at peak times of the year. The team's testing also included 100 and 500 micrograms/liter, which would characterize a "spilling event" in real life, such as heavy rains following a fresh application of the chemical, Fraser said.

The team's method, unlike most techniques, doesn't detect atrazine concentrations directly. Instead, it watches for the toxic chemical's effects on phytoplankton (algae and blue-green algae within the water "column" being evaluated). Atrazine blocks

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Urban 'heat island' contrast changes with seasons

While the residents may not necessarily agree, a University of Nebraska-Lincoln graduate student can prove that certain towns in southeastern Nebraska are indeed "hot spots."

Limin Yang, a graduate student with the UNL Center for Advanced Land Management Information Technologies (CALMIT), working with fellow grad students Luoheng Han and Wenli Yang, has completed the most detailed study of the contrast between urban and rural surface radiant temperature ever done in Nebraska. He presented their findings at the annual meeting of the Nebraska Academy of Sciences April 16 at Nebraska Wesleyan University in Lincoln. CALMIT is a unit of the Conservation and Survey Division.

Surface radiant temperature (SRT) refers to thermal energy emitted from the ground. The SRT of urban areas is greater than that of rural areas, sometimes called the "heat island" effect. This study shows how that difference changes with the seasons and offers some reasons why.

The study revealed that the contrast between rural and urban SRTs is higher during the growing season, from March to October. The contrast is highest from June to September. The team calculated differences between rural and urban SRTs ranging from about seven to 16 degrees Fahrenheit--four to nine degrees Celsius--in those peak months of the growing season.

Yang said the higher contrast of rural and urban

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faces and places. Certain activation functions are used send information through the interconnectiosns. They are the workhorses of the program: they compare and contrast the new information with the images already stored in memory, looking for matches. (Our mind does this too, on an unconscious level. That's how we recognize familiar faces and places--they've been matched with the images stored in our memory.) When the search is complete, the results are then sent to the output layer.

The output layer is the top end of the program, where the processed information emerges with a classification attached. The output layer could consist of a simple "yes" or "no" channel--yes, the new information was matched with information stored in memory, or no, it wasn't (in other words, yes, I recognize that face, or no, I don't). In a more complex program, several output channels, each corresponding to a different image, would process the images. (When looking at a group of your friends, your brain would have a different "output channel" corresponding to each of them, telling you who you're looking at.)

What's the upshot of all this? You can put an image in one end of the neural network and it will spit out an answer at the other end, telling you what it's been looking at, all without using complex statistical models where a large number of samples must be collected and collated to yield accurate results.

First, however, the network must be trained. In Yang and Han's study, seven training-site aerial photographs from Clay County, each one corresponding to a different land-cover type, was put into the network. These "training sets" give the network a base of information in its memory, against which to match new information. When new data from new sites were fed into the program, it identified the land-cover types they displayed with the above-mentioned 99.58 percent accuracy. Given the small training set the program was using, this is a very impressive result.

However, Yang said the neural network method for classifying land cover isn't intended to replace the traditional statistical method. It's a different method, not necessarily a superior one, he said.

The neural network method is useful when data used for the statistical method is scarce or may be faulty, Yang said. For instance, if there aren't many samples of the land cover available, or if the data yielded from the samples is highly variable, the neural network method is probably better, he said. The network doesn't need many samples to work from, and isn't affected by skews in the data that might throw the statistical method off.

If accurate samples and adequate data distribution can be obtained, the statistical method is probably preferred, because it is slightly more accurate, Yang said.

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SRTs during the growing season can be attributed to different land-cover characteristics, especially the "canopy" of growing plants in rural areas. The plants absorb sunlight and consume its energy for photosynthesis and evapotranspiration. Not much heat is radiated from the canopy and the air above it. In contrast, building surfaces and roads in cities absorb and store the sun's energy readily, causing the relatively large differences in SRT between rural and urban areas during the growing season.

It's a different story during the winter months. Stripped of plant canopies, rural areas emit more thermal radiation. Bare soil will heat up quickly; little energy is used for photosynthesis or evapotranspiration. The SRT of urban areas is still greater than that of rural areas during the winter, but the contrast is much lower than during the growing season.

Studies of SRT contrasts have been done in the past, but this study used more images than others--16 compared to perhaps one or two, Yang said. With values for urban and rural SRTs recorded at various times of the year, the team was able to show how the contrast between the two changed over the course of the year, something earlier studies couldn't do, Yang said.

The data used in the study was for 1990, collected by the AVHRR satellite and made available to CALMIT by the EROS Data Center in Sioux Falls, South Dakota. Areas of Douglas, Sanders, Sarpy, Lancaster, Cass, Washington, and Dodge counties were included in the sample. Data from 1991 and possibly 1992 will be analyzed as well, Yang said. He also said he hopes the results of the study will eventually be incorporated into a surface climate model he is working on, which would have a large number of applications in a variety of fields.

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Research at Wildcat Ridge revamps land mammal ages

Research on rock formations in western Nebraska has resulted in the revision of the ages of the time represented by two North American land mammal ages, according to Jim Swinehart, a geologist with the UNL Conservation and Survey Division (CSD). Animals living during this period included ancient horses, rhinos, cats, dogs, rodents, marsupials and the last known North American primate.

The project at Wildcat Ridge, which runs through Scotts Bluff National Monument and includes Chimney, Courthouse and Jail rocks, has challenged many assumptions about the geology of the White River and Arikaree groups, two of the major geologic units of the Nebraska Panhandle, Swinehart said.

Swinehart's collaborators on the project include Robert Diffendal, Jr. of CSD, Carl Swisher of the University of California-Berkeley, Donald Prothero of Occidental College in Los Angeles and Richard Tedford of the American Museum of Natural History in New York. Swinehart said the project, in addition to revising land mammal ages, has also contributed to a better understanding of these rocks and the changing geography and depositional environments of Nebraska over time.

The Gering Formation, the oldest part of the Arikaree Group, was the original basis for the beginning of the Arikareean land mammal age, which is dated at about 18 to 30 million years ago. A land mammal age is defined by the first and last occurrences of particular fossil animals. Then, by dating volcanic ashes within the rock layers in which particular "sets" of fossils are found, a time frame for the occurrence of that set of animals (an age) is obtained.

The Gering Formation was thought to span about 3 million years of the Arikareean age, but more precise dating has revealed that it only covers about 300,000 years, Swinehart said. A redating of such magnitude is important because it brings into question theories about rates of evolution and sedimentation gleaned from the rock groups, he said.

In addition, the Arikareean and Whitney ages are now believed to have been longer than once thought, Swinehart said. Originally the Arikareean was thought to have begun 28 million years ago, and the Whitney, 29 million years ago. New evidence indicates that the Arikareean actually began 30 million years ago, and the Whitney, 32 million years ago, doubling the length of the Whitney, Swinehart said.

Two interesting techniques were used to define the dates of rock layers in the ridge, Swinehart said. An argon-argon technique developed about five years ago was used to date individual crystals in ash beds, he said. The technique, which uses argon 39 and argon 40 to measure radioactive decay, is more accurate than an older method. In this technique, a laser aimed at a single grain of sand causes the grain to evaporate. This is more precise than the old method, which required more grains, raising the possibility of older grains being mixed with new ones, thus possibly throwing off the accuracy of the dating.

An assessment of paleomagnetism was also used to correlate and thereby help date the rock layers. Every million years or so, the earth's magnetic poles reverse, and this pattern of reversals can be detected in rock layers. The pattern can be used to correlate different sets of rocks. Rock units that used to be continuous but have been interrupted by erosion or other forces can be identified. For example, paleomagnetic data helped better correlate strata in the South Dakota Badlands, about 125 miles north, with those of the Panhandle's Wildcat Ridge, Swinehart said.

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photosynthesis in phytoplankton. Unable to use the life-giving energy of the sun, the algae will either compensate for the toxic substance or die. Along the way, the spectral "signature" it emits changes.

Those spectral changes can be detected by remote-sensing equipment, in this case, the Spectron Engineering SE-590 spectroradiometer, a device for measuring electromagnetic radiation from various bands. The testing took place in summer 1991 at the Kansas Aquatic Mesocosm Program (KAMP) site, a University of Kansas facility near Lawrence used for testing of toxic materials. The team set up 14 "limnocorrals" (enclosures holding about 55 gallons of water each) in a testing pond and treated each with a different concentration of atrazine. They then took scans of each enclosure using the spectroradiometer. When analyzing the data, they were clearly able to see changes in the phytoplankton's spectra caused by atrazine.

Although the study is preliminary due to lack of repeat testing (only one scan each day was taken of each of the 14 enclosures), the team believes this methodology holds considerable promise. They tried to repeat the testing last summer but were hampered by scheduling problems and a lack of cloud-free days needed for reliable collection of spectral data, Fraser said. The team plans to try again this summer, with an expanded battery of tests that are hoped to yield statistically significant (and therefore publishable) results, he said.

Testing for atrazine this way could lend itself to practical applications as well. Natural resource managers could use high-resolution imaging equipment in a plane, coordinating with people collecting limited numbers of water samples on the ground, to determine the amount of atrazine contamination in a given area, he said. Alternatively, they could use a spectron to take scans, assuming they have access to the equipment. Either method would probably be faster and cheaper than chemically testing large numbers of water samples for atrazine, which is the traditional method, Fraser said.

The test may also be adapted to detect other toxic chemicals in the future, Fraser said. The team didn't necessarily choose atrazine for their study because they view it "as the number one evil chemical," Fraser said, but because it's the most widely applied pesticide in the United States.

Panhandle wells tops in oil and gas production again in 1992

The Nebraska Panhandle continued to lead the state in oil and gas production in 1992, according to various oil and gas journals.

The Kleinholz Field, reopened on April 6, 1986, with the discovery of a deeper oil-producing horizon, was once again Nebraska's leading oil producer despite a slight slowdown. Located in Kimball County, the field produced more than 1.5 million barrels of oil from 28 wells in 1992.

The Terrestrial Field, also located in Kimball County, accounted for most of the other oil production in the Panhandle. Opened in 1990, the field produced over 123,000 barrels of oil from eight wells last year.

Both fields also yielded small amounts of gas and traces of water.

In Cheyenne County, about 15 miles northeast of Sidney, Fort Worth-based Snyder Oil Corp. continued operating six gas wells. The wells tap the Niobrara Formation, which underlies the western four-fifths of Nebraska. In 1992 they produced more than 228 million cubic feet of gas.

Visiting Chinese scholar to study land-cover classification at CALMIT

A visiting scientist from China, Li Jiuming, will be working with the Center for Advanced Land Management Information Technologies (CALMIT) until May 1994. A native of Beijing, he arrived in mid-March. CALMIT is a unit within the Conservation and Survey Division of the University of Nebraska-Lincoln.

Jiuming will be working with James Merchant, CSD research geographer and associate director of CALMIT, on a land-cover database that is a joint effort with the U.S. Geological Survey. He brings with him an extensive background in geography, geographic information systems (GIS) and remote-sensing systems from Peking University and the Chinese Academy of Sciences in Beijing. He has also been a guest researcher in the Remote Sensing Laboratory of the Physical Geography Department of Stockholm University. While at CALMIT, Jiuming will be working on new techniques for using remote sensing and GIS technology to show land cover on a continental scale.

Jiuming said this issue is very important because land-cover change is directly related to global environmental change and problems such as the greenhouse effect. Any significant change in land cover means changes in photosynthesis rates, which in turn means changes in global carbon dioxide and oxygen levels.

The greenhouse effect means the capacity of gases such as carbon dioxide and methane to trap heat radiated from the earth after it reaches the planet's surface. An increase in these gases during the last 200 years has created concern about global warming caused by human activity.

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