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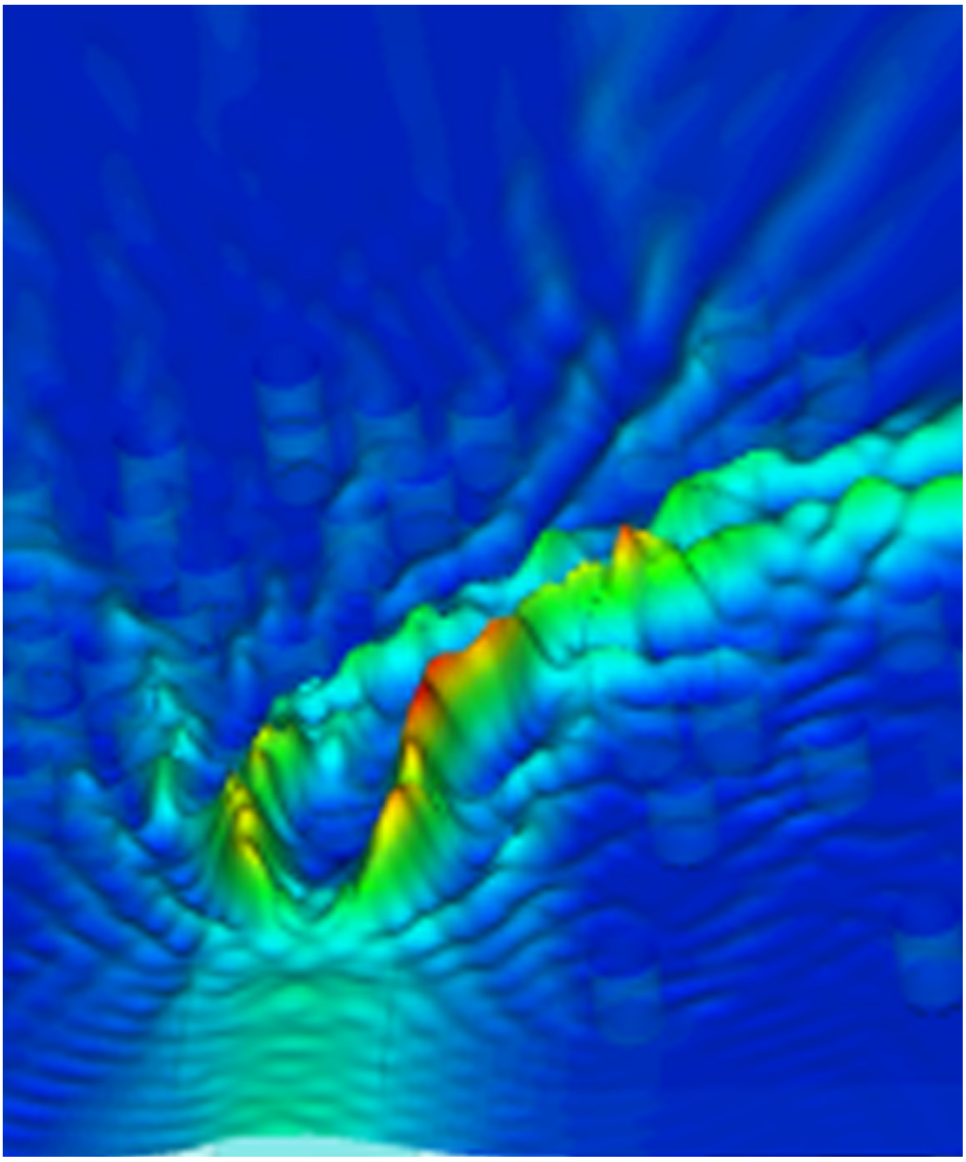
Single-molecule logic proposed

Scheme calls for making logic gates from individual molecules.



System susses out silent speech

Sensing throat and tongue nerve signals lets computers hear silent speech.

Bacteria make clean power

A fuel cell powered by microbes makes electricity from wastewater.

Irregular layout sharpens light

Odd crystal promises precise optical control.

... and more

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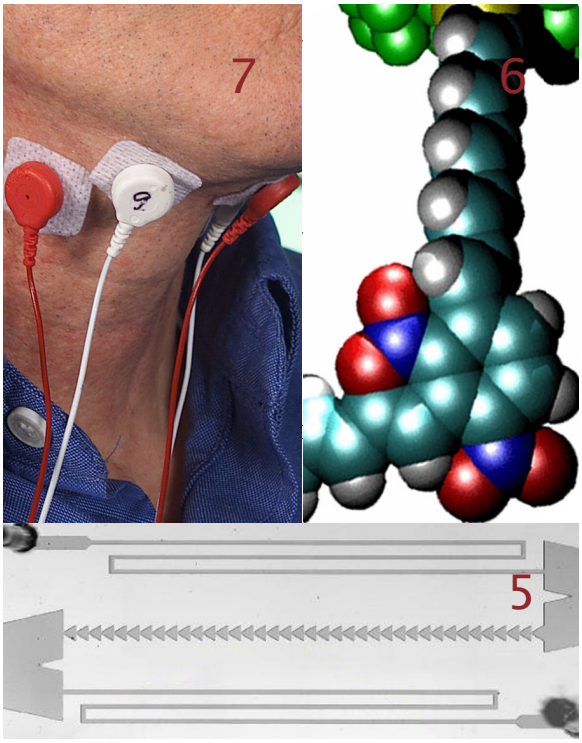
Contents:

Briefs



Stories

Single-molecule logic proposed

Chipmakers can make circuits only so small before the laws of physics change the ground rules. Researchers are looking to make logic circuits by linking individual molecules, and some are even considering how to make logic circuits within molecules. The quantum nature of molecules all but rules out using traditional circuit design, but it also opens new possibilities for building the basic components of computer chips.

Page 6

System susses out silent speech

One day computers might be able to interpret brain signals, allowing people to control computers using only thought. A NASA system that reads nerve signals destined for the throat and tongue is a step in that direction. The system interprets patterns in the signals when a person silently speaks, allowing a computer to recognize commands without hearing a sound.

Page 7

Virtual people look realistically

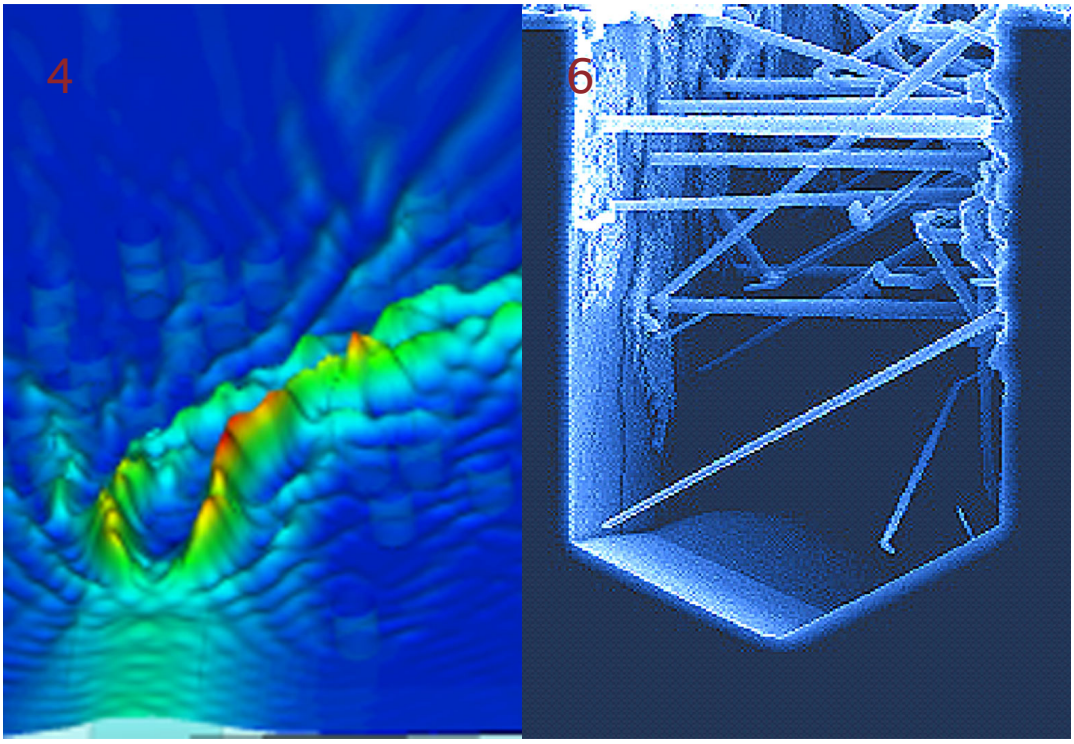
Adding a bit of memory to a model of visual reflexes gives virtual reality characters a more realistic gaze. The idea is to keep a character from looking at the same bright red chair every time he walks into his virtual living room.

Page 8

Pulse trap makes optical switch

Computers might run entirely on light someday. But there's a lot of work to do between now and then. A key challenge is finding efficient ways of using light pulses to switch light pulses. One possibility is using one type of light pulse to trap another.

Page 9



fact

Speech occurs when the lungs pipe air into the trachea and through the vocal cords in the larynx. This creates a vibrating air column that is massaged into speech by the pharynx, tongue, lips and teeth. The 5th 7th and 12th cranial nerves control movement and sensation in the tongue, and the 9th and 10th cranial nerves control the muscles of the larynx.

quote

"We have demonstrated a simple [subvocal speech] Web browsing application where we use a digit code to enter items in a Web browser and navigate around pages."

- Chuck Jorgensen, NASA

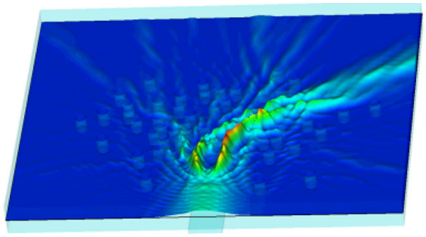
Cover image source: University of Southern California

Briefs

Irregular Layout Sharpens Light

Photonic crystal is semiconductor material with regularly spaced rods or holes that is designed to guide certain wavelengths of light.

University of Southern California researchers have found that the broken symmetry of aperiodic photonic crystal, or crystal that does not contain repeating patterns, can be better than ordinary photonic crystals at functions like filtering light. The researchers have developed a computer program that can be used to find aperiodic photonic crystal designs that behave a certain way.



Source: University of Southern California

This graphic shows a simulation of a light-wave bending at a 60 degree angle as it passes through an irregular photonic crystal. The colored peaks represent the most intense portions of the lightwave.

Aperiodic photonic crystal could improve devices that shape, detect and filter light, including communications devices like photodetectors, demultiplexers, which sort wavelengths of light, and channel drop filters, which filter out different wavelengths. The material could also be tapped to transfer light beams from optical fibers to regular photonic crystals.

The researchers' program simulates a photonic crystal and randomly moves one of its rods. If this makes the crystal better able to filter light according to a set goal, it is kept. The program runs through many steps until the goal is met.

The researchers' simulation took 9,700 steps to produce a configuration that bent light at a 45-degree angle and kept the beam's intensity tightly focused into a top-hat shape. This shape in the intensity profile of the beam is nearly impossible to achieve using regular photonic crystal, according to the researchers.

Aperiodic photonic crystals could be used in practical applications in five years, according to the researchers The work appeared in the February 1, 2004 issue of the *Journal of Applied Physics*.

TRN

Bacteria Make Clean Power

Researchers have previously shown that is possible to build a fuel cell run by microbes.

Pennsylvania State University scientists have done them one better.The Penn State researchers' microbial fuel cell is fueled by wastewater skimmed from the settling pond of a treatment plant, and the process of drawing electricity from the microbial action taking place in the wastewater also cleans the water.

The researchers' prototype produced as much as 50 milliwatts of power per square meter of electrode surface. Fifty milliwatts is about five percent of the electricity need to light a mini Christmas tree light.At the same time, the process removed as much as 78 percent of the organic matter in the wastewater, according to the researchers. The device handles wastewater that contains particulate material.

The device runs using bacteria that are naturally present in the wastewater. As the bacteria break down wastewater materials they pass electrons to the fuel cell's negative electrode. This pumps the electrons through a wire to form a useful current. The electrons return through the cell's positive electrode and combine with hydrogen ions and oxygen to form water.

An economical prototype of the microbial fuel cell could be produced in five years, and a practical commercial device within ten years, according to the researchers. The work is slated to appear in *Environmental Science and Technology*.

TRN

Curve Widens 3D Display

Although three-dimensional screens have been around in different forms for decades, they generally have downsides. Some types require glasses, and those that don't usually cannot be viewed from much more than a 15-degree angle or are fairly dim.

Researchers from Seoul National University in Korea have showed that using curved lenses doubles the viewing angle of three-dimensional integral imaging systems without sacrificing brightness.

The technique could eventually be used for three-dimensional billboards and three-dimensional television, according to the researchers.

Integrated imaging systems project sections of images through an array of lenses. The sections are combined, or integrated, at a point in front of the display to produce a 3D image. These displays have a limited viewing angle because the image sections must be wider the farther they are from the center of the display, and can be only so wide before they overlap.

The researchers' prototype uses a lens array that is curved rather than flat. This increase is the viewing angle because the lenses are angle around the viewer, which helps keep the image sections proportional.

There is some work to be done before the method is ready for prime time, however, according to the researchers. In order to present an image free of gaps between image sections, the screen must be slightly curved as well. Technologies like plastic electronics and electronic paper are poised to deliver flexible screens.

The technique could be used in applications like three-dimensional advertising displays within two to four years. Three-dimensional television systems are at least a decade away, according to the researchers. The work appeared in the February 9, 2004 issue of *Optics Express*.

TRN

Triangles Form One-Way Channels

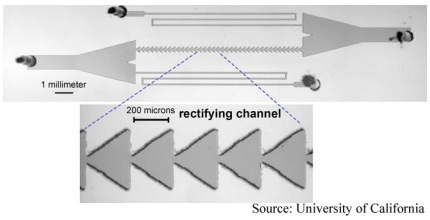
California Institute of Technology researchers have designed a microfluidic rectifier that is simply a channel whose shape makes flow resistance different for fluids flowing in opposite directions.

This makes it act like a diode, which allows electricity to flow in only one direction, or a mechanical check valve, which blocks fluids from reversing direction.

Flow in the reverse direction faces more than twice the resistance of forward flow.

The microfluidic rectifier could be used in integrated microfluidic circuits, which use control fluids to operate pumps and valves that move samples and reagents in biochips.

The active element of the device is a chain of 43 triangles running down the middle of the channel. The channel is 100 microns deep.The triangles are 230 microns from base to tip, and 330 microns wide. A micron is one thousandth of a millimeter.



Source: University of California

This microfluidic channel resists the flow of a polymer liquid in only one direction due to the properties of liquid and the channel's shape.

Key to the achievement is the type of fluid the researchers used — a viscoelastic polymer that has long, chain-like molecules that entwine like strands of thread. The molecules stretch as the fluid passes through a constriction, and eventually the molecules unravel, which increases the fluid's flow resistance at a greater rate than the increase in applied pressure.

One advantage of the researchers' simple design is that it relatively easy to fabricate. The microfluidic rectifier is a single mold sealed with a glass cover.

The method could be implemented within a year, according to the researchers. The work is scheduled to appear in an upcoming issue of *Physical Review Letters*.

TRN

DNA Has Nano Building in Hand

Researchers from Ludwig Maximilians University in Germany have built a simple molecular machine from DNA that can bind to and release single molecules of a specific type of protein.

The DNA hand can be made to select any of many types of proteins, and could eventually be used to construct materials or machines molecule-by-molecule.

The researchers used DNA branch migration, a method that allows a DNA nanostructure to switch between several arrangements of its parts, to construct the DNA hand. In one configuration, the structure contains an open sequence of bases that binds to a specific protein, and so can grab that type of protein. A second configuration does not contain the open sequence, and so drops the protein.

The rearrangements are reversible, allowing the tiny machine to repeatedly grab and drop a molecule of a specific type of protein.DNA aptamers, or strands that bind to specific molecules, can be selected from a pool of DNA sequences, making it possible to construct a DNA hand that binds to any type of protein, according to the researchers.

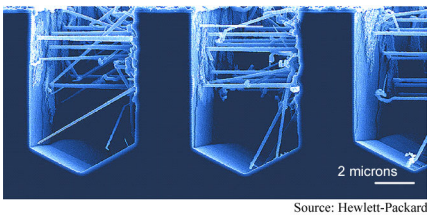
The researchers demonstrated the DNA hand by having it repeatedly grab and drop molecules of the protein Thrombin.

The DNA hand could be used in simple nano construction applications in two to five years, and in more advanced applications in five to ten years, according to the researchers. The work is scheduled to appear in an upcoming issue of *Angewandte Chemie International Edition*.

Nanowires Span Silicon Contacts

One challenge for researchers aiming to make electronics at the size-scale of molecules is finding ways to position and attach nanowires to the tiny components.

Researchers from Hewlett-Packard Laboratories and have grown nanowires between electrodes that were made using common patterning techniques. Because the nanowires grow and connect automatically, the method promises to provide a relatively inexpensive way to mass-produce nanoelectronics.



Source: Hewlett-Packard

These silicon nanowires span a pair of electrodes that form a trench in a silicon wafer.

The method could be used to make hand-held devices that can sense very small amounts of chemicals. The nanowire arrays create a large surface area for contacting target substances like toxic chemicals or pathogens. The method could also eventually be used to make interconnecting leads between nanowires and also devices like transistors within nanowires, according to the researchers.

The researchers used a chemical vapor and a metal catalyst to coax dense arrays arrays of nanowires to form between a pair of vertical silicon electrodes. The electrodes were the side walls of a trench etched in a silicon wafer. The method is compatible with existing chip-making processes, according to the researchers.

Practical applications are about five years away, according to the researchers. The work appeared in the January 23, 2004 issue of *Nanotechnology*.

TRN

Stories

Single-Molecule Logic Proposed

By Eric Smalley, Technology Research News

Researchers from the French National Center for Scientific Research (CNRS) and University College London in England have devised a scheme for designing logic circuits within individual molecules.

The scheme could eventually be used to produce small, fast computers and to store large amounts of data in very small spaces. The method could also be modified to make sensors for detecting individual molecules.

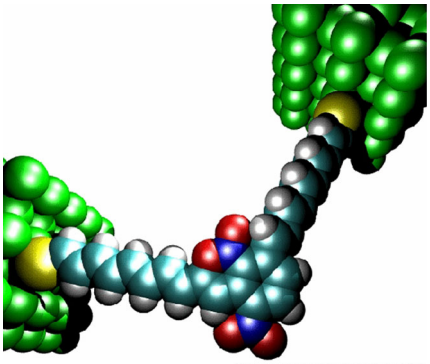
The researchers' plan calls for connecting a pair of benzene molecules to two gold electrodes. The molecules contain nitrogen-oxygen side groups whose rotational positions can represent the 1s and 0s of computer information. The researchers' simulations show that the set-up would allow for simple two-input logic gates like AND and XOR, said Robert Stadler, an assistant professor of physics and astronomy at University College London.

An AND gate contains two inputs and one output. If the inputs are the same — either a pair of 0s or a pair of 1s — the gate returns an output of 1. If the inputs are different, the output is 0. An XOR gate returns a 1 if either or both of the inputs are 1.

The molecular circuits also have the potential to perform more complex functions, said Stadler. "We envision [a] move towards complexities where a far larger number of inputs can be processed through a single molecule," he said.

The researchers hit upon the idea while they were trying to build another molecular logic design and encountered problems with parts of molecules interfering with each other. The previous attempt copied the structure of larger, diode-based logic circuits, said Stadler. "There we encountered problems with quantum interferences," he said. "So we decided to try to use those interferences for information processing rather than trying to avoid them."

The logic scheme works because a molecule guides electrons passing through it as quantum waves rather than as particles passing through larger electrical circuits. "By changing the chemical side-groups, the geometry of the waveguide can be tuned," said Stadler. Depending on how the side-groups are rotated, they are coupled or decoupled from the cloud of electrons associated with the benzene molecule. The side-group positions represent inputs and two side groups provide the requisite number of inputs for the two basic logic gates.


Source: University College London

This diagram shows a benzene molecule configured as an XOR logic gate. Each sphere represents an atom. The red and dark blue spheres represent the molecule's side groups, which can be rotated to change the molecule's electrical conductance. The green shapes are electrodes.

Changing the electronic structure of the molecule by rotating the side groups changes the interference pattern of the different paths the electron waves can travel through the molecule, which changes the electrical conductance of the

molecule. The conductance levels represent logic gate's output.

There are several technical challenges to implementing even a simple version of the molecular logic, said Stadler. The first challenge is bringing a large number of electrodes within nanometers of each other. A nanometer is one millionth of a millimeter. "Gap sizes of about five nanometers between two electrodes are now possible," he said. "But for more than two electrodes this of course becomes increasingly difficult."

A second challenge will be positioning the molecules on electrodes, said Stadler. "In situ manipulation of the molecules when they are anchored on electrodes is the next big hurdle," he said.

Finally, to construct a working information processing or storage system, molecules must be interconnected. "This raises a large number of architectural and manufacturing issues," said Stadler.

At this early stage, it is difficult to predict exactly how well such molecular devices will work. In addition to the performance of a single molecular system, interconnections among the molecules and a means of connection to the larger world must be taken into consideration, said Stadler. "These interconnections and the detailed computer architecture of the whole system will be [the] limiting factors for performance in density rather than properties of the molecules themselves," he said.

Practical applications for molecular electronics are more than a decade away, said Stadler. They "should not be expected before 2015," he said.

Even further down the road, molecular electronics could be coaxed to interact with a chemical environment, said Stadler. "Prospects for medical applications, where molecular devices could be linked to bio-chemical processes would be very exciting," he said. These possibilities won't be realized anytime soon, he added.

Stadler's research colleagues were S. Ami and Christian Joachim at CNRS in France and Michael Forshaw at University College London. The work appeared in the January 23, 2004 issue of *Nanotechnology*. The research was funded by the European Community and the Consortium for Hamiltonian Intramolecular Computing.

Timeline: 10 years
Funding: Government
TRN Categories: Biological, Chemical, DNA and Molecular Computing
Story Type: News
Related Elements: Technical paper, "Integrating Logic Functions inside a Single Molecule," *Nanotechnology*, January 23, 2004

TRN

System Susses out Silent Speech

By Eric Smalley, Technology Research News

When you talk there's a lot more going on than just sound.

Scientists from the NASA Ames Research Center are taking advantage of the nerve activity that happens near the throat when humans speak in order to gain information about what a person is saying.

The researchers have shown that the sub auditory, or silent electrical signals in the throat can be tapped for speech recognition interfaces and communications. The researchers capture signals through two pairs of sensors stuck under the chin and on either side of the throat and use a computer to interpret the signals. These nerve signals — muscle control signals that the brain sends to the tongue and vocal cords — are present whether a person speaks audibly or silently.

The method could be used to augment acoustics in noisy environments, in computer speech recognition, and in space where acoustics are distorted by unusual breathable gas mixtures and different pressures, said Chuck Jorgensen, chief scientist for neural engineering at NASA Ames Research Center. "Subvocal methods can augment the speech to minimize errors," he said.

It could also eventually be used when privacy is needed, for injured or handicapped users, and to add information like mood, fatigue or intent to the communications channel, said Jorgensen.

Source: NASA

These electrodes pick up nerve signals bound for the throat and tongue. The signals are then processed by a computer to identify silently spoken words and numbers.

The researchers' prototype recognizes six words and the digits 0 through 9, and has an accuracy rate of 92 percent, according to Jorgensen.

The researchers have constructed a pair of prototype applications. The first uses subvocal signals to allow a user to browse the Web. A user silently speaks numbers to spell out two-digit codes that represent each letter of a search term. The search results are numbered, and a user silently speaks the numbers to choose Web pages.

The second application allows a user to silently control a Mars rover. "We have a real-time control demo of a Mars rover which we can sub vocally move around terrain," said Jorgensen them. The prototype uses the words stop, go, left, right, alpha, and omega. Alpha and omega are general control

words that represent pairs of functions like faster/slower or up/down depending on context.

The system discerns words from the electromyelogram/electropalatogram (EMG/EPG) readings of nerve signals that control vocalization in larynx and tongue muscles. The system learns to match features in the waveforms of the readings to the six words and 10 digits. A user must first train the system by saying the words and digits repeatedly.

The nerve signals are measured by sensors attached to the skin on the side of the throat to pick up signals bound for the larynx, and on the soft tissue under the chin to pick up signals bound for the tongue.

A user is able to speak silently using the method because the signals are tapped at a point before they are used to vocalize speech. The method picks up signals when a person is speaking silently using almost no muscle movement, according to Jorgensen.

Key to the method is that vocal muscle control signals must be very precise and repeatable in order for speech to be understood by other people.

The researchers used a mixed wavelet/neural network coding scheme to analyze the signals, said Jorgensen. The muscle signals picked up by the sensors are amplified and filtered to tease out certain patterns present in the waveforms, then the information is fed into a neural network pattern classifier that learns and organizes the signal patterns in real time.

Neural networks mimic biological brains and have the capacity to learn. They're composed of simple processor units that are comparable to neurons. The connections among the units get stronger the more they are used, and repeated exposure to the same or similar information produces a distinct neural pattern that can be used to identify subsequent input.

The researchers first presented the work in July, 2003 at the International Joint Conference on Neural Networks in Portland, Oregon. Since then they have made the system work in real time and decreased training time, said Jorgensen. "We have dropped the learning requirements from several hundred examples to 50 or less per word, and can train in the morning and be running in the afternoon," he said.

The researchers are now working on using the method in full-blown speech recognition systems, said Jorgensen. "We're working on vowel and consonant separation," he said.

They are also testing new sensors that can read muscle signals through clothing. "We're developing an entirely new sensor architecture based not on surface electrodes, but on capacitive field coupling," said Jorgensen.

The method could be used in practical applications that contain limited vocabularies in less than three years, said Jorgensen. It will be more like five years before the method can be used in connection with full-blown speech recognition systems, he said.

Jorgensen's research colleagues were Diana D. Lee and Shane Agabon. The research was funded by the National Aeronautics and Space Administration (NASA).

Timeline: > 3 years
Funding: Government
TRN Categories: Human-Computer Interaction
Story Type: News
Related Elements: Technical paper, "Sub Auditory Speech Recognition Based on EMG/EPG Signals," International Joint Conference on Neural Networks (IJCNN), Portland, Oregon, July 2003

TRN

Virtual People Look Realistically

By Kimberly Patch, Technology Research News

The first time you enter a room, you probably look around quite a bit to see what's there. The second time you enter the room, you'll probably look around a little less.

Researchers from Trinity College in Ireland have added memory to a neurobiological model of visual attention in order to generate more realistic animation for virtual reality characters.

The idea is to endow characters with internal characteristics like memory and attention that can guide their movements, according to Christopher Peters, a computer science researcher at Trinity College.

The key to providing a character with an internal representation of its environment is memory, said Peters. "The memory system provides a means of storage for information about what the character has previously perceived."

The researchers' gave the the characters synthetic vision modules that provided the sensory input to a memory model. The memory model used the classic stage theory psychological model that delineates memory as long-term and short-term to find information that should be stored for a longer period of time.

Source: Trinity College Dublin

This computer model takes into consideration the user's perception of where other people's attention is focused.

The setup allowed a character to determine whether it had seen an object before, said Peters.

The researchers modeled gaze behavior because it is related to visual perception and memory, and it also forms the basis of many higher-level behaviors, said Peters. "For example,

if something in our environment provokes our interests, we may orient or senses toward that stimulus in order to enhance its processing," he said. If the stimulus proves dangerous, "we may behave so as to avoid it or leave the area."

The challenge was figuring out, given an internal representation, or memory, of an environment, what parts of the representation would take precedence in attracting a character's interest, said Peters. "If you're walking down the street, what determines the priority [of what you] look at?" he said.

Attention has to do with allocating processing resources in systems — like living beings — that are only capable of limited processing, said Peters. "In terms of gaze, we may decide to elaborate our processing of certain stimuli by looking directly at them," he said. The researchers found that a gaze model recently developed by University of Southern California researchers fit the bill.

The USC model simulates the early visual processing areas in the primate brain; it shows that very basic neural feature detectors in three areas of the brain probably explain a lot of how attention is directed to particular objects in scenes. Feature detectors detect areas like edges and color blobs. The model uses maps of feature detectors, and discounts maps that contain too little or too much activity while amplifying regions that have an activity level that is significantly different from other regions. Each feature map highlights one or a few regions that are different from the rest.

The Trinity researchers combined the scene-based attention metrics from the USC attention module with object-based information from their memory module to find objects in a scene that attract a character's attention because they account for temporal changes in the scene like character or object movement, said Peters.

The researchers' gaze generator module depicts appropriate gaze and blinking motions based on factors derived from psychology literature to provide a final animation for the virtual human, said Peters.

One of these factors is a head-move attribute, which defines how likely the character is to turn his head to look at an object. Another concerns the relationship between blinking and gaze shifts. It is common behavior to blink at the start of a head or eye movement, and such blinking is more probable as the size of the gaze shift increases, according to Peters.

The researchers are currently refining their models to add task-driven attention requirements. They are also looking into adding an auditory sense, according to Peters.

The ultimate goal is to provide virtual humans whose gaze behaviors are indistinguishable from real humans, said Peters.

A real-time virtual human performance that involves a full attention system will be practical in three to six years, said Peters. Peters' research colleague was Carol O'Sullivan. They presented the results at the Association of Computing Machinery (ACM) Special Interest Group Graphics (Siggraph) 2003 conference in San Diego, July 27 to 31.

The research was funded by the higher education authority of Ireland (HEA).

Timeline: 3-6 years
Funding: Government
TRN Categories: Human-Computer Interaction; Data Representation and Simulation
Story Type: News
Related Elements: Technical paper, "Attention-Driven Eye Gaze and Blinking for Virtual Humans," Association of Computing Machinery (ACM) Special Interest Group Graphics (Siggraph), San Diego, July 30, 2003

TRN

Pulse Trap Makes Optical Switch

By Kimberly Patch, Technology Research News

Scientists who work with light pulses so short that one trillion of them pass by in a second are laying the groundwork for higher bandwidth communications and blazingly-fast, all-optical computer chips.

But making the most of these ridiculously short pulses requires that they be switched on and off using other light pulses rather than electronic devices. Researchers have been working on all-optical switching for decades; the challenge is finding a fast, efficient method that uses little power.

Researchers from Nagoya University in Japan have found a way to capture an ultrashort pulse by using a second pulse to filter out the first one as it travels through an optical fiber. Selectively knocking out pulses from a string, or train, of pulses makes for a sequence of pulses and gaps that can represent the ones and zeros of digital information. Using light pulses to do this means that, like electronic circuits, the output of one logic unit can control another.

The method takes advantage of a phenomenon known as optical pulse trapping — meaning one optical pulse can overlap with and travel with another. "The trapped pulse spatially overlaps with [a] control pulse and they copropagate along the fiber," said Norihiko Nishizawa, an assistant professor of quantum engineering at Nagoya University.

The researchers demonstrated the method by sending a train of signal pulses down an optical fiber, then picking off one of the pulses in the train by making a control pulse overlap the targeted signal pulse. "We can trap [a single] pulse from high-repetition-rate pulse trains," said Nishizawa. The method is nearly 100 percent efficient, he said.

As the pulses propagate down a fiber optic line, the waveform of the trapped pulse is compressed into a shorter wavelength. The control pulse is a soliton, a type of wave that doesn't normally spread out as it travels. Solitons can be made to shift to a longer wavelength, and when a soliton that is trapping another pulse shifts, the trapped pulse is forced to shift to a shorter wavelength to compensate.

The shift makes it possible to identify and pick off only the trapped pulses, said Nishizawa. "Since the wavelength of the trapped pulse is distinctly shifted and separated from the other untrapped pulses, we can pick off only the trapped pulse easily using [a] wavelength filter," he said.

The researchers used an ultra-fast optical pulse device that they demonstrated in 1999 to provide light pulses separated by only 1.5 picoseconds, or trillionths of a second. A trillionth of a second is to a second as a second is to 31,709 years.

This is equivalent to a communications rate of .67 terahertz, or trillion bits per second, according to Nishizawa. The method could make it possible to use pulses separated by one picosecond to provide a communications speed of one terahertz, he said. Today's high-speed communications equipment uses tenth of a nanosecond pulses to provide top communications speeds of 10 billion bits per second per channel.

The researchers modified a crosscorrelation frequency resolved optical grating (X-FROG) system to measure the ultrashort optical pulses so they could prove that the system worked. The test system provided the researchers with spectrograms that showed the wavelength of light passing through at any given trillionth of a second. "We have developed a highly sensitive X-FROG system so that we could directly observe the ultrafast all-optical switching," said Nishizawa.

The pulse trapping method could eventually be used in ultrafast optical communications, and optical information processing, said Nishizawa.

The idea of using soliton trapping gates is not new, but the researchers are using a different physical effect — the compensating shift of the trapped pulse — to filter out pulses, said Curtis Menyuk, a computer science and electrical engineering professor at the University of Maryland Baltimore County.

The method is one of a large number of proposed all-optical switching schemes, said Menyuk. The Nagoya method is relatively intricate and delicate, however. Its drawbacks are that the range of allowed powers and frequencies is small, and the approach doesn't make it possible to cascade more than one device, he said.

The researchers' next step is demonstrating the method at the 1.55 micron wavelength region used for long distance optical communications.

Nishizawa's research colleague was Toshio Goto. The work appeared in the February 24, 2003 issue of *Optics Express*. The research was funded by the Japanese Ministry of Education, Science, Sports and Culture.

Timeline: 5 years
Funding: Government
TRN Categories: Optical Computing, Optoelectronics and Photonics
Story Type: News
Related Elements: Technical paper: "Ultrafast All Optical Switching by Use of Pulse Trapping across Zero-Dispersion Wavelength," *Optics Express*, February 24, 2003.