Innovations Report

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ICT

Nokia and MIT researchers are teaching cell phones to take commands in natural language.

As part of a research collaboration with MIT computer scientists, the Nokia Research Center Cambridge, in Cambridge MA, is developing cell phones that can understand and respond to written commands typed in English.
Robert Iannucci, head of the center, says the company wants to transform phones from simple calling terminals to "information gateways" -- to the Internet, GPS and sensors, MP3s, desktop computers, iPods, and other devices. And, he says, that requires rethinking the entire interface between people and handhelds. For both Nokia and MIT, that means using text interaction.

Natural language navigation systems have been long on promise and short on delivery. But it's no longer unrealistic to think these systems may be in the hands -- and handsets -- of consumers in the near future. One caveat: the complex underpinnings of these new applications and the algorithms that parse language will have to be hidden from cell-phone users -- lest they get frustrated navigating through layers of menus.

To power Nokia's natural language technology, MIT's Katz is using a software system he developed in 1993 called Start, which interprets human questions and finds answers using websites such as the Internet Movie Database (IMDB) and Mapquest. Using the Web version of Start as a base, Katz is currently working with the Nokia center to develop a mobile version of the software for cell phones, called MobileStart.

The most obvious change this kind of interaction would make for users is a simplifying of the complex menu structures that have evolved as cell phones handle more tasks. By using a natural-language navigation system, users can perform functions without digging through layers of menus or sifting through dozens of Google hits on a tiny screen. The mobile version of Start can also glean information from a phone's GPS device and the Web, or interact with and send commands to applications on the phone, such as an address book and calendar.
The language commands will also enable people to have their various technologies communicate with other's devices, removing entirely the need to send a dizzying array of text messages, e-mails, and voice mails to others.
Of course, with more complex actions -- such as interacting with other devices -- Start and other natural-language navigation software systems begin to bog down. MobileStart should also be able to deal with more complicated preference issues.
Currently, the Start system knows only English (although it can access Google's language tools to translate phrases). Its parsing system -- what it uses to divide a query into object, property, and value -- could be used with any human language, but Katz will need to teach it a new vocabulary and syntax for each new language.

Ideally, says Katz, MobileStart will be combined with voice-to-text software to make using cell phones even easier. With this attempt to make natural languages and technology compatible, Nokia is entering the Web 2.0 movement]. Nokia is trying to make its mobile devices more user-friendly and reduce the interface problems that keep devices from being as practical as they can be. Indeed, Nokia's Iannucci points to the frustrating irony that "cell phones are inherently voice devices, but they don't use voice as a modality."

A Universal Chip for Cell Phones

A single chip for wireless devices that's multifunctional, more energy efficient, and space saving is in the works

A prototype for the "receiver" portion of a "universal" wireless chip that can receive radio frequencies ranging from 800 megahertz to 6 gigahertz -- which could eliminate the need for multiple chips in mobile devices, extend their battery life, and make them smaller.
Research out of the University of California, Los Angeles (UCLA) has shown that a single wireless chip -- call it the "universal" chip -- could be in cell phones, as well as other wireless gadgets, in as few as three years, extending their battery life, allowing for sleeker designs, and permitting them to access features beyond Wi-Fi, GPS, global phone service, and Bluetooth.

Today's cell phones can contain up to six wireless radio chips, which send and receive information in the form of electromagnetic waves. Each chip has a specific function: there's one designed to work at the frequency of the cellular carrier's signal and others for Wi-Fi, GPS, and Bluetooth frequencies. Although some chip makers have built and deployed "triband" and "quadband" chips that can tune into three or four different bands, designing a truly universal chip that can access all frequencies has remained a challenge.
But the incentive is there: a phone with a universal chip could access any service on the spectrum -- from local television and radio, to Wi-Fi and WiMax -- in addition to saving power and precious space within shrinking gadgets. This universal chip would provide flexibility similar to that of a car radio tuner, allowing most stations to be ignored, and zeroing in on just one frequency.
The UCLA team has designed a chip that is capable of accessing all the incoming radio signals, he says, over a spectrum from 800 megahertz to 5 gigahertz. Its work relies on a technological concept called "software-defined radio," or SDR. SDR is based on the concept of converting all incoming radio signals (which are electromagnetic waves and therefore analog) into digital 1s and 0s. This would enable a circuit's software to sort through different frequency bands, and pick out the one of interest. Using software bypasses the need to design and add a specific radio for each band.

Ultrafast Network Will Get Speedier in 2007

Internet2, the dedicated network for data-intensive researchers and corporations, will be at least 10 times faster.

By sending data using different colors of light, operators of the ultrahigh-speed Internet2 network are hoping to boost capacity by as much as 80-fold to enable researchers to connect telescopes around the world and perform other bandwidth-intensive tasks.
The new network should be in place by fall 2007, said Douglas Van Houweling, Internet2's chief executive.

He announced the plans this week as researchers set a new networking speed record -- 8.8 gigabits per second, nearing the Internet2's current theoretical limit of 10 Gbps, which is thousands of times faster than standard home broadband connections. "We have applications now that need more than 10 gigabits of capacity,".

The Internet2 network, which parallels the regular Internet to let universities, corporations and researchers share large amounts of information in real time, currently uses shared fiber optic cables run by Qwest Communications International Inc.
In the new network, Internet2 will have the cables all to itself. Operators will initially be able to transmit data using 10 colors, or wavelengths, of light over a single cable, giving the network a capacity of 100 Gbps. Eventually, Internet2 hopes to transmit on 80 wavelengths.
Although the ability to send data using multiple wavelengths isn't new, Van Houweling said Internet2 will be deploying new circuits that can each interpret all 10 wavelengths.

The new network will still be run by a contractor, which Van Houweling wouldn't name.

Water and Nanoelectronics mix to create Ultra-dense Memory Storage Devices

Excessive moisture can typically wreak havoc on electronic devices, but now researchers have demonstrated that a little water can help create ultra-dense storage systems for computers and electronics. A team of experimentalists and theorists at the University of Pennsylvania, Drexel University and Harvard University has proposed a new and surprisingly effective means of stabilizing and controlling ferroelectricity in nanostructures: terminating their surfaces with fragments of water. Ferroelectrics are technologically important "smart" materials for many applications because they have local dipoles, which can switch up and down to encode and store information. The team's work is reported in the April issue of Nano Letters.

"It is astonishing to see that a single wire of even a few atoms across can act as a stable and switchable dipole memory element," Jonathan Spanier, of Drexel U., said. Spanier and his colleagues successfully demonstrated the benefits of using water to stabilize memory bits in segments of oxide nanowires that are only about 3 billionths of a meter wide.

In this investigation, led by Hongkun Park of Harvard and Andrew Rappe of Penn, the researchers probed oxide nanowires individually to characterize the size-dependence of ferroelectricity and performed calculations and experiments to validate the presence of molecules on oxide surfaces and detail their important role in nanoscale ferroelectricity. Significantly, these results show that ferroelectric surfaces with water fragments or other molecules can stabilize ferroelectricity in smaller structures than previously thought.

Though a scheme for the dense arrangement and addressing of these nanowires remains to be developed, such an approach would enable a storage density of more than 100,000 terabits per cubic centimeter. If this memory density can be realized commercially, a device the size of an iPod nano could hold enough MP3 music to play for 300,000 years without repeating a song or enough DVD quality video to play movies for 10,000 years without repetition.

Microelectronics & Nanotech

Quantum Paint-on Laser Could Rescue Computer Chip Industry

Researchers at the University of Toronto have created a laser that could help save the $200-billion dollar computer chip industry from a looming crisis dubbed the "interconnect bottleneck."
But this isn't a laser in the stereotypical sense. In fact, Ted Sargent, professor in charge of the work, carries a small vial of the paint used to make this laser in his briefcase.

Lasers that can produce coherent infrared light in the one to two nanometre wavelength range are essential in telecommunications, biomedical diagnosis and optical sensing. The speed and density of computer chips has risen exponentially over the years, and within 15 to 20 years the industry is expected to reach a point where components can't get any faster. But the interconnect bottleneck -- the point where microchips reach their capacity -- is expected sometime around 2010.

To tackle this problem, Sargent created the new laser using colloidal quantum dots -- nanometre-sized particles of semiconductor that are suspended in a solvent like the particles in paint. "We've made a laser that can be smeared onto another material," says Sargent. "This is the first paint-on semiconductor laser to produce the invisible colours of light needed to carry information through fiber-optics. The infrared light could, in the future, be used to connect microprocessors on a silicon computer chip."
They crystallized precisely the size of the nanoparticles that would tune the colour of light coming from the laser. They chose nanoparticle size, and thus colour, the way a guitarist chooses frets to select the pitch of the instrument. Optical data transfer relies on light in the infrared--beams of light 1.5 micrometers in wavelength travel farthest in glass. And they made their particles just the right size to generate laser light at this wavelength.

The laser's most remarkable feature is its simplicity. But also “the wavelength and the thermal budget of the Toronto laser are very appealing for applications in optical interconnects," as experts say. "The performance is excellent, particularly the temperature insensitivity of the output wavelength."

A study describing the laser was published in the April 17 issue of the journal Optics Express.

The microchip industry is looking for components that exist on the scale of transistors and are made of semiconductors, which would produce light when exposed to electrical current. With this development, it could be possible to use the electronics already found on microchips to power a laser that communicates within the chip itself.

Nanogenerators Convert Mechanical Energy To Electricity For Self-powered Devices

Researchers have developed a new technique for powering nanometer-scale devices without the need for bulky energy sources such as batteries. By converting mechanical energy from body movement, muscle stretching or water flow into electricity, these "nanogenerators" could make possible a new class of self-powered implantable medical devices, sensors and portable electronics.

Described in the April 14th issue of the journal Science, the nanogenerators produce current by bending and then releasing zinc oxide nanowires -- which are both piezoelectric and semiconducting. The research was sponsored by the National Science Foundation (NSF), the NASA Vehicle Systems Program and the Defense Advanced Research Projects Agency (DARPA).

"We can build nanodevices that are very small, but if the complete integrated system must include a large power source, that defeats the purpose"
The nanogenerators developed by Prof. Wang of Georgiatech, use the very small piezoelectric discharges created when zinc oxide nanowires are bent and then released. By building interconnected arrays containing millions of such wires, Wang believes he can produce enough current to power nanoscale devices.

The arrays contained vertically-aligned nanowires that ranged from 200 to 500 nanometers in length and 20 to 40 nanometers in diameter. The wires grew approximately 100 nanometers apart, as determined by the placement of the gold nanoparticles. A film of zinc oxide also grew between the wires on the substrate surface, creating an electrical connection between the wires. To that conductive substrate, the researchers attached an electrode for measuring current flow.

Though attractive for use inside the body because zinc oxide is non-toxic, the nanogenerators could also be used wherever mechanical energy -- hydraulic motion of seawater, wind or the motion of a foot inside a shoe -- is available. The nanowires can be grown not only on crystal substrates, but also on polymer-based films. Use of flexible polymer substrates could one day allow portable devices to be powered by the movement of their users.
Current could also be produced by placing the nanowire arrays into fields of acoustic or ultrasonic energy. Though they are ceramic materials, the nanowires can bend as much as 50 degrees without breaking.

The next step in the research will be to maximize the power produced by an array of the new nanogenerators. Wang estimates that they can convert as much as 30 percent of the input mechanical energy into electrical energy for a single cycle of vibration. That could allow a nanowire array just 10 microns square to power a single nanoscale device -- if all the power generated by the nanowire array can be successfully collected.

Scientists reveal how a novel ceramic achieves directional conduction

An international team led by UCL (University College London) scientists at the London Centre for Nanotechnology has unravelled the properties of a novel ceramic material that could help pave the way for new designs of electronic devices and applications.

Working with researchers from the Swiss Federal Institute of Technology (ETH), Zurich, the University of Tokyo and Lucent Technologies, USA, they reveal in a Letter to Nature that the complex material, which is an oxide of manganese, functions as a self-assembled or 'natural' layered integrated circuit. By conducting electricity only in certain directions, it opens up the possibility of constructing thin metal layers, or racetracks, insulated from other layers only a few atoms away.

Currently, the race for increasingly small and more powerful devices has relied on two-dimensional integrated circuits, where functional elements such as transistors are engineered via planar patterning of the electrical properties of a semiconductor. Packing more functionalities into tiny electronic devices has until now been achieved by reducing the lateral size of each component, but a new realm of opportunity opens with the ability of building three-dimensional structures.

Professor Gabriel Aeppli, Director of the London Centre for Nanotechnology and co-author of the study, explains: "There is an issue of how you deal with leakage between layers when you pack circuits into three dimensions. Our work with the Tokyo-Lucent groups shows that you can have many layers with little or no leakage between them. This is because we're not dealing with ordinary electrons, but with larger objects, consisting of electrons bound to magnetic and other disturbances of the atomic fabric of the material, which can't travel across the barriers between layers."

The flow of electricity in modern electronic devices relies on the fact that electrons move readily in certain solids, such as metals like copper, and are blocked from moving in insulators such as quartz. In ordinary solids, electrons move similarly in all three dimensions, therefore if a material is metallic along one direction, it will be metallic in all directions. The ceramic – a manganese oxide alloy with the chemical formula $La_{1.6}Sr_{1.4}Mn_2O_7$ – has fascinated scientists for a decade due to the extraordinary sensitivity of its electrical properties to magnets placed near it. Most interesting was the discovery by the University of Tokyo group that even quite small magnets can switch electrical currents in the same way in this ceramic as in much more expensive, individually fabricated electronic devices of the type being tested for advanced magnetic data storage.

Using one of the classic tools of nanotechnology, the scanning tunnelling microscope, Dr Henrik Rønnow (ETH) and Dr Christoph Renner (LCN and UCL) swept a tiny metallic tip with sub-atomic accuracy over the surface of the ceramic to sense its topographic and electronic properties at spatial resolution of less than the diameter of a single atom. The data showed that this ceramic behaves like a perfect metal along the planes parallel to the surface and like an insulator along the direction perpendicular to the surface.

The results also revealed the first snap-shot of a possible culprit for this unusual electronic behaviour. In conventional solids, charge is carried by simple electrons, but in such ceramics, it is shuttled around by more complex objects, known as polarons, which consist of electrons bound to a magnetic disturbance as well as local displacements of atoms away from their ordinary positions.

Life Sciences

Cure For Cancer Worth $50 Trillion, Study Says

A new study, to be published in a forthcoming issue of the Journal of Political Economy, calculates the prospective gains that could be obtained from further progress against major diseases. Kevin M. Murphy and Robert H. Topel, from University of Chicago, estimate that even modest advancements against major diseases would have a significant impact -- a 1 percent reduction in mortality from cancer has a value to Americans of nearly $500 billion. A cure for cancer would be worth about $50 trillion.

"We distinguish two types of health improvements -- those that extend life and those that raise the quality of life," explain the authors. "As the population grows, as incomes grow, and as the baby-boom generation approaches the primary ages of disease-related death, the social value of improvements in health will continue to rise."
Many critiques of rising medical expenditures focus on life-extending procedures for persons near death. By breaking down net gains by age and gender, Murphy and Topel show that the value of increased longevity far exceeds rising medical expenditures overall. Gains in life expectancy over the last century were worth about $1.2 million per person to the current population, with the largest gains at birth and young age.
"An analysis of the value of health improvements is a first step toward evaluating the social returns to medical research and health-augmenting innovations," write the authors. "Improvements in life expectancy raise willingness to pay for further health improvements by increasing the value of remaining life."

Murphy and Topel also chart individual values resulting from the permanent reduction in mortality in several major diseases -- including heart disease, cancer, and diabetes. Overall, reductions in mortality from 1970 to 2000 had an economic value to the U.S. population of $3.2 trillion per year.

Engineers Creating Small Wireless Device To Improve Cancer Treatment

Engineers at Purdue University are creating a wireless device the size of a rice grain that could be implanted in tumors to tell doctors the precise dose of radiation received and locate the exact position of tumors during treatment.
Researchers at Purdue's Nanotechnology Center have tested a dime-size prototype to prove the concept and expect to have the miniature version completed by the end of summer, said Babak Ziai, un of the work coauthors. "Currently, there is no way of knowing the exact dose of radiation received by a tumor," Ziaie said. "And, because most organs shift inside the body depending on whether a patient is sitting or lying down, for example, the tumor also shifts. This technology will allow doctors to pinpoint the exact position of the tumor to more effectively administer radiation treatments by using three or six coils placed around the body to pinpoint the location of the electronic device. The device, a "passive wireless transponder," has no batteries and will be activated with the electrical coils placed next to the body.

“It will be like a capsule placed into the tumor with a needle," said Ziaie. Researchers tested the prototype with a radioactive material called Cesium. The device, which contains a miniature version of dosimeters worn by people in occupations involving radioactivity, could provide up-to-date information about the cumulative dose a tumor is receiving over time.

The technology uses the same principle as electret microphones, popular products found in consumer electronics stores. The microphones contain a membrane that vibrates in response to sound waves. Between the membrane and a metal plate is an air gap that serves as a capacitor, or a device that stores electricity. As the membrane vibrates, the size of the air gap changes slightly, increasing and decreasing the capacitance and altering the flow of electric current through the circuit, creating a signal that transmits information stored in the dosimeter.
"It's basically like a very small tuning circuit in your radio," Ziaie said. "This will be a radiation dosimeter plus a tracking device in the same capsule. It will be hermetically sealed so that it will not have to be removed from the body."

Research findings were appeared earlier this year in proceedings of the 19th IEEE International Conference on Micro Electro Mechanical Systems.

What makes us age? Researchers think cell nuclei may hold part of the answer

Blocking a aberrant protein could keep cells pert and young.

In the continued quest to pinpoint the molecules that turn us wrinkly and grey, some scientists are beginning to think that the walls of the cell nucleus might play an important role.
A new study shows that cells from people over the age of 80 tend to have specific problems with the nucleus that young children's cells do not. The elderly nucleus loses its pert, rounded shape and becomes warped and wrinkled.

The discovery supports the up and coming idea that at least part of the normal ageing process may be driven by the nucleus' decay, and that blocking this might curb some of time's toll upon the body. "If this really has a physiological role in normal elderly people then it's a huge deal," says David Sinclair from Harvard Medical School.

Researchers have found many different genes that can alter the lifespan of animals. In addition, some environmental factors, from the amount of food we eat to the number of cigarettes we smoke, are thought to contribute to the speed at which we age. But there is no consensus yet on how, exactly, these things combine to make our cells and bodies start to fail. One widely held idea is that cells accumulate wear and tear over a lifetime from damaging molecules known as reactive oxygen species. Some researchers have focused on problems with the power-generating components of cells, called mitochondria. And others have looked at how the ends of chromosomes, called telomeres, fray as we get older.

To gain insight into human ageing, in recent years some biologists have focused their attention on a group of diseases known as progerias, in which children can suffer baldness, heart disease and other symptoms of premature ageing. In 2003, scientists showed that one such rare disorder, called Hutchinson-Gilford progeria syndrome (HGPS), is caused by a mutation that affects the lamin A protein, a building block of the nucleus and its wall. Now Tom Misteli and Paola Scaffidi at the National Cancer Institute in Bethesda, Maryland, have shown that elderly people tend to have the same problem with their cell nuclei, suggesting that this protein is important in the normal ageing process.

In cells taken from the elderly, the nuclei tend to be wrinkled up, the DNA accumulates damage, and the levels of some proteins that package up DNA go askew, the team reports in Science. This mirrors the same changes that they previously observed in cells from HGPS children. The team suggests that healthy cells always make a trace amount of an aberrant form of lamin A protein, but that young cells can sense and eliminate it. Elderly cells, it seems, cannot.

Critically, blocking production of this deviant protein corrected all the problems with the nucleus. "You can take these old cells and make them young again," Misteli says.
This suggests that drugs that do the same thing might slow or stay some symptoms of ageing. This is the next key experiment that needs to be tried in animals, researchers say.

New non-invasive imaging method

New York University's Alexej Jerschow, an assistant professor of chemistry, and Norbert Müller, a professor of chemistry at the University of Linz in Austria, have developed a completely non-invasive imaging method. Their work offers the benefits of magnetic resonance imaging (MRI) while eliminating patients' exposure to irradiation and setting the stage for the creation of light, mobile MRI technology. The research, which appears in the latest issue of the Proceedings of the National Academy of Sciences (PNAS), was supported by the National Science Foundation.

MRI allows clinicians to non-invasively visualize soft tissue in the interior of the human body through the application of radiofrequency (rf) irradiation. However, the rf pulses of MRI machines deposit heat in patients and medical staff, though safety regulations that limit energy deposition have long been established. Jerschow and Müller have devised a low-energy, nuclear magnetic resonance (NMR) technique that does not require external rf-irradiation. Their technique, instead, relies on the detection of spontaneous, proton spin-noise in a tightly coupled rf-cavity.

Very strong magnetic fields, as generally required for MRI and NMR, can be avoided with the spin-noise detection scheme, making possible the development of extremely portable and minimally invasive MRI and NMR instruments.