Innovations Report

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ICT

Plotting The Road Ahead For Wireless Sensor Networks

Wireless sensor networks consisting of multiple objects, each capable of simple sensing, actuation, communication and processing have tremendous potential. To better realise their full capabilities researchers are developing a broad vision of innovative future applications.

Wireless sensor networks are a typical example of a network of 'cooperating objects', tiny embedded computers that cooperate together to produce an intended result. Such embedded systems, be they tiny processors in 'intelligent clothing' or the increasing numbers of computers in automobiles, are characterised by their need to interact with their immediate surroundings. However, it is only by cooperation with other objects that the full capabilities of such networks can be reached. The problem faced by system designers is that, with so many cooperation possibilities with other networks, intelligent objects or even users themselves, how are they to know the best research direction to take? Which possibilities are likely to be taken up by society and industry globally, and which will turn out to be a blind alley?

These are the questions that the IST project Embedded WiseNts aims to answer. The project has brought together twelve partners from ten different European countries, the top research institutions in wireless communication, distributed computing and cooperating objects, to come up with some answers.
The project partners are focusing on the development of Wireless Sensor Networks (WSN) and their applications, especially in the form of Cooperating Objects (CO), to help develop a roadmap for innovative future applications. Their objective is to gain a broad vision of embedded wireless networks in the future (+/- 10 years), what their requirements would be and what technical progress is needed to this end.

Specifically, project researchers are looking at the current state-of-the-art in four key areas:
* Typical application scenarios.
* Algorithms used for routing, service-discovery, etc.
* The vertical system functions that impact on several software layers, such as security, context and location management, exception handling, etc.
* System architecture and programming models, how to develop middleware that could be used for cooperating objects in applications, hardware interfaces, industry applications, etc.

Embedded WiseNts ends in December 2006. The project's findings are already feeding into other research areas associated with cooperating objects. One example is the IST project AWARE, a new project which is examining the possibilities for using cooperating objects in combination with robotics.

Cognitive Radio

Smart radios and other new wireless devices will avoid transmission bottlenecks by switching instantly to nearby frequencies that they sense are clear

Engineers are now working to bring a flexible operating intelligence to future radios, cell phones and other wireless communications devices. During the coming decade, cognitive radio technology should enable nearly any wireless system to locate and link to any locally available unused radio spectrum to best serve the consumer. Employing adaptive software, these smart devices could reconfigure their communications functions to meet the demands of the transmission network or the user.

Cognitive radio technology will know what to do based on prior experience. On the morning drive to work, for instance, it would measure the propagation characteristics, signal strength and transmission quality of the different bands as it rides along with you. The cognitive radio unit would thus build an internal database that defines how it should best operate in different places and at specific times of day. In contrast, the frequency bands and transmission protocol parameters of current wireless systems have been mostly fixed.

As cognitive radios send and receive signals, they will nimbly bound in and out of free bands as required, avoiding those that are already in use. This automatic channel jumping should permit cognitive radio systems to transmit voice and data streams at reasonable speeds. By making much more efficient use of existing radio-frequency (RF) resources to work around spectrum-availability traffic jams, wireless communications should become far more dependable and convenient and perhaps considerably cheaper than it is today. Indeed, if cognitive radio technology progresses as its developers hope, a glut of RF-spectrum options may actually arise in time.

However, cognitive radio is arriving on the heels of the next-generation wireless technology, called software-defined radio (SDR), that uses both embedded signal-processing algorithms to sift out weak radio signals and reconfigurable code structures to receive and transmit new radio protocols. The change means, for example, that SDR code running on a standard computer, fitted with a RF peripheral component interconnect card could allow the computer to behave a standard TV. If the computer is fitted with an analog RF SDR card, it could upload software programming that would allow it to behave as a cellular handset or base station, a wireless personal organizer or even a military-frequency radio--whatever is required (and permitted) for the task at hand.

This new wireless paradigm involves SDR systems that can reconfigure their analog RF output and that incorporate "self-awareness" and knowledge of transmission protocols, etiquette and procedures. These developments will yield a cognitive radio able to sense its RF environment and location and then alter its power, frequency, modulation and other operating parameters so as to dynamically reuse whatever spectrum is available.

Cognitive Radio technology would also cause a major restructuring of the Wireless Web organization and economics.
In traditional cell-phone systems, most of the intelligence for efficient operation resides in the network. Customers need a contract with a service provider to obtain access to the network and then to the public switched-telephone network. Cognitive radio technology, in contrast, embeds the intelligence required to connect to wireless networks in the radio handset, laptop or wireless

organizer. Because a cognitive control subsystem governs the SDR capabilities, a unit can detect RF-networking opportunities wherever it finds itself.

The same thing will happen for computers with WLAN capabilities. Cognitive radio will have the operational intelligence to rent or borrow WLAN and other RF spectrum quickly for seconds or minutes at a time in exchange for "spectrum cash," a verifiable promise to loan the cognitive radio's own picocell capabilities to another cognitive radio in the future. From these wireless Web access points, the Internet service provider would then transfer the user's data or call to anyone, anywhere in the world. One can see then that cognitive radio does not need a dedicated cellular network to connect a user via wireless and the Internet to other devices. In addition, as the cognitive radio interactions with the wireless Web expand, the need for a long-term contract with a cellular-service provider diminishes.

Wi-Fi and Cellular Coming Together

Now, manufacturers and mobile carriers are preparing to link standard cellular networks to the mishmash of Wi-Fi hotspots, a move that will expand coverage and perhaps make cheaper mobile minutes a reality. The technology, called Unlicensed Mobile Access, or UMA, will help those who have high-speed Wi-Fi routers overcome any poor coverage in their houses or apartments. It's also a way for mobile carriers to expand their footprint without spending lots of money on new infrastructure. UMA could enable users of souped-up handsets to wirelessly download content at broadband speeds at home and take that on the road when they leave.

UMA works by tunneling cellular information packets through the Internet when Wi-Fi is available and reverting to cellular towers when it is not. A back-end controller inside the network makes the switch. Voice minutes over Wi-Fi networks are far cheaper than minutes on cellular networks because they use free radio spectrum and the Internet and do not require large cell towers.

"Everything from multimedia to audio, video -- when you look at the capabilities of phones now, the options expand pretty quickly," Nokia spokesman Eric Estroff said.

At the conference in Las Vegas last week, Samsung Electronics Co. Ltd. unveiled its t709 phone capable of seamlessly accessing Wi-Fi and cellular networks. Nokia's 6136 and Motorola Inc.'s A910 were introduced in February at a conference in Spain.

ABI Research expects the market for Wi-Fi enabled mobile handsets to reach 100 million units annually by 2009. Carriers in Europe have expressed interest. France Telecom SA has said it will be Nokia's first European customer for its UMA phones, while Nordic operator TeliaSonera AB said in February it is moving ahead with trials for business customers.

Nearly 200 U.S. cities have announced plans to offer Wi-Fi hotspots free of charge. But The US market is still cautios, and most of U.S. carriers are tightlipped about when they might roll out the service and at what price

Holograms Break Storage Record

New technology has almost twice the storage density of a magnetic hard drive.

Holographic storage company InPhase Technologies announced this week that it has broken a storage density record by writing 64.3 gigabytes of data onto a single square inch of disc space. This advance could eventually lead to a holographic disc that can hold more than 100 DVD-quality movies, according to the company. By comparison, magnetic disks, such as those in the hard drives of computers, can manage a storage density of about 37.5 gigabytes per square inch of disk.

Kevin Curtis, chief technology officer of InPhase, explains that while magnetic storage -- the leading option for storing large amounts of data -- is quickly approaching its physical limit, holographic storage will grow rapidly without major technological overhauls for at least another five to six years.

The concept of using a hologram -- a three-dimensional image generated by lasers -- to store information dates back to the 1960s (see Holographic Memory). But it's only been within the last five years that the optical storage technology has become feasible, says Demetri Psaltis, professor at the California Institute of Technology. One reason the technology is now more commercially viable is because the lasers needed to read and write data have become smaller and cheaper.

Other types of optical storage disks -- CDs, DVDs, Blu-Ray, HD DVD -- also use lasers to read and write information. However, they can keep data only on their surfaces, whereas holographic products store data in three dimensions -- the key to holding an entire movie library on a single disc.

To write three-dimensional information to a disc, engineers exploit the fact that beams of light, when crossed in a certain way, generate holograms. The process begins as a single blue laser beam is split into the signal beam and reference beam. Information is encoded into the signal beam as a pattern of light and dark pixels, representing 0s and 1s. When the signal beam is crossed with the reference beam, a three-dimensional hologram of the array of pixels is imprinted into a photosensitive medium in the disc.

This array is called a "page" of data; InPhase's discs contain about 1.3 million bits of data per page, says Curtis. Furthermore, he explains, multiple pages can be placed at slightly different angles to each other, to make up what he calls a "book." Angling the pages allows the engineers to place numerous pages within the same three-dimensional disc space, maximizing the amount of data that can be stored within a disc.

Microelectronics & Nanotech

Spray-on silicon

Reports of the death of silicon electronics may well have been exaggerated. A technique that allows the deposition of silicon films from solution could harbinger the era of the inkjet-printed circuit.

In Nature April issue, Shimoda et al. set forth a radical way of incorporating silicon into that most basic of electronic components, the transistor. Their technique uses a novel liquid precursor of solid silicon to allow the 'printing' of semiconductor films via familiar inkjet technology. It could thus permit unprecedented control over the size and placement of semiconducting silicon in future generations of high-performance electronic equipment.

Semiconducting silicon is obtained from highly purified natural silicon by adding tiny amounts of appropriate impurities (the process known as doping), or through specialized crystallization methods. Whichever way is chosen, enormous effort goes into extracting, refining, shaping and processing silicon to make it technologically useful.

Recently, the need for semiconducting transistors to help transform electricity into coloured light for displays and screens has begun to present a challenge for existing silicon manufacturing technologies. In particular, the demand for screens with ever-increasing pixel resolution that are thinner, brighter, wider and lighter — or even flexible — has stretched the solid-state patterning techniques used to produce silicon circuitry to the limit. It has also fuelled intense research into alternative, more processable semiconducting materials, including organic molecules and polymers. Electronic devices based on solid layers of silicon still provide the benchmark for semiconductor performance, however.

Conventional techniques for their manufacture involve, for instance, heating ultra-pure silicon in a vacuum to create a mist of free silicon atoms that condenses onto a supporting surface, but multiple refining and deposition steps are required and, once deposited, the solid film must be sliced or etched to produce circuit elements, and then attached to the rest of the electronic components. All this must be done without compromising silicon's semiconducting properties. That places severe limits on semiconductor thickness, patterning and connectivity, a major problem in particular for the mass production both of very small devices and of displays that cover huge areas. In both such applications, it is difficult to consistently reproduce transistor size, thickness and pattern using solid-state techniques.

Scientists have therefore looked for liquid-phase processing techniques. Sophisticated, high-resolution printing technologies already exist that could be used to introduce very thin layers of liquid semiconductor in complex patterns over a variety of surfaces. But the technique showed by Shimoda and colleagues to process silicon in the liquid phase is far simpler than the previous ones.

They worked on a binary compound of silicon and hydrogen, Si5H10 or cyclopentasilane, that is liquid at room temperature. When baked at a temperature of 300 °C or higher, this compound loses hydrogen gas, leaving a residue of pure, elemental silicon. Using a technique called 'ring-opening' on to the five-membered silicon rings in the cyclopentasilane liquid, unfortunately a volatile liquid, causing them to open and join end-to-end they were able to improve the silicon output of this baking process. The amorphous network of silicon atoms, a-Si, obtained by this process does not have the optimum three-dimensional structure for semiconducting behaviour, and so, as a final step, high-intensity ultraviolet light is applied to rearrange it into a more ordered, polycrystalline form (poly-Si).

Shimoda and colleagues are thus the first to produce relatively high-performance silicon films by processing from solution. They first prepared films by simple spin coating — essentially, spraying a thin layer of solution onto a quartz surface before baking — and found that the properties of the films were comparable to those of high-quality poly-Si produced by conventional techniques. Although this performance was lower for films deposited using inkjet-printing technology, it was still much higher than is typically achieved for solution-processed films based on alternative, organic materials.

This method dispenses with some high-temperature refining of metallurgical silicon extracted from silica and replaces it with chemical synthesis and milder distillations. Admittedly, the liquid precursor is highly sensitive to contamination by oxygen both during and after its preparation. Such contamination can drastically diminish the electronic performance of the eventual film, and dictates that air and water must be rigorously excluded at all stages of the process. These precautions are, however, no different from those taken for traditional routes to silicon thin films.

But it is the potential for taking advantage of highly controlled printing techniques in the patterning of silicon thin films that makes this work particularly exciting.

It might be that, in the end, inkjet printing of 'liquid silicon' will not provide the resolution necessary to pattern a high-density integrated circuit and therefore make a computer chip. But what it will certainly allow is the remarkably straightforward generation of simple, cheap and flexible circuits for displays, as well as a range of other applications — solar cells, X-ray detectors and multi-analyte chemical sensors included.

New nanomaterial synthesis method created

Virginia Commonwealth University chemists in Richmond, Va., say they've developed a method for the synthesis of nanomaterials. The scientists say the technique, which uses a microwave oven, can control the dimensions and properties of nanoscale rods and wires.
The method, known as microwave irradiation, or MWI, is considered a fast and easy way to create highly versatile, tailored nanorods and nanowires because microwave heating can provide significant enhancement in reaction rates.

"MWI is unique in providing scaled-up processes thus leading to a potentially important industrial advancement in the large-scale synthesis of nanomaterials," said M. Samy El-Shall, lead author of this study. El-Shall said the advantage of using a microwave is that the energy goes directly through molecules compared with thermal heat, which applies heat to everything. In addition, El-Shall said nanorods and nanowires made by the microwave method self-assemble into uniform aligned arrays of rods with well-controlled spacing. His findings were published in the March ACS journal.

Nanodots may unlock power of superconducting wires

The next generation of superconducting wires, which could operate efficiently at the high temperatures needed to make applications such as levitating trains feasible, has been created by researchers.
For 20 years, researchers have worked to develop the perfect high-temperature superconducting wires to replace today's copper-based power grid. But the secret, it now seems, is to build flawed ones. The key may be to position non-conducting nanodots at strategic points within the wire. Electrical current flowing through superconducting materials experiences virtually no resistance, enabling wires of the material to carry high current loads very efficiently. However, such a powerful current will disrupt itself because it produces a strong, fluctuating magnetic field.

By depositing lines of 10-nanometre-wide, non-conducting dots of barium zirconate at fixed distances along the wire, researchers at Oak Ridge National Laboratory, Tennessee, US, have found a way to disrupt current flow in just the right way to tone down these fluctuations.
"The potential applications for high-temperature superconducting materials are so significant that the people who discovered them were awarded Nobel prizes the year after their announcement," says Amit Goyal, one of the wire's developers. "But we still don't have a physical understanding of how they work, so getting anywhere near these applications has taken two decades. Now we may see some steps forward soon."
The wires, made of yttrium barium copper oxide (YBCO), will first be worked into lightweight and powerful rotating machinery such as generators and motors, says Venkat Selvamanickam, head of materials research at Superpower Inc.

However, Selvamanickam says, the "killer app" for these wires will be as the infrastructure of tomorrow's electrical grid. A typical modern electrical grid based on copper wires can ferry current along with just under 90% efficiency. A grid based on an infrastructure of high-temperature superconducting wires could be more than 97% efficient. Right now, that is too small a change to merit the cost of installation, says Paul Grant, one of the patent holders of YBCO and a consultant for the US government's department of energy.
However, large areas of high power consumption are starting to become problematic for current grids, as was shown by the widespread blackout in Canada and the US in August 2003. Superconducting wires play a large role in building stable grid structures, not only as transmission cables but also as components in transformer stations and other maintenance equipment.

Not that the remaining technological challenges are insignificant. The method Oak Ridge used to produce the wires only spins out lengths measured in inches, rather than miles. There are two techniques for producing longer wires, but it is unclear how they could accommodate the inclusion of nanodots. Also, the term "high temperature" is somewhat of a misnomer. Such superconducting materials, in this case YBCO, need to be cooled to around -200°C (conventional superconductors only work at near absolute zero temperatures, closer to -273°C). This means that a system that circulates liquid nitrogen along the wires would need to accompany any installation. Fortunately liquid nitrogen is inexpensive, which means that superconducting wire applications such as levitating trains would become economically feasible.

MIT researchers build tiny batteries with viruses

MIT scientists have harnessed the construction talents of tiny viruses to build ultra-small "nanowire" structures for use in very thin lithium-ion batteries. By manipulating a few genes inside these viruses, the team was able to coax the organisms to grow and self-assemble into a functional electronic device. The goal of the work, led by MIT Professors Angela Belcher, Paula Hammond and Yet-Ming Chiang, is to create batteries that cram as much electrical energy into as small or lightweight a package as possible. The batteries they hope to build could range from the size of a grain of rice up to the size of existing hearing aid batteries.

Batteries consist of two opposite electrodes - an anode and cathode - separated by an electrolyte. In the current work, the MIT team used an intricate assembly process to create the anode. Specifically, they manipulated the genes in a laboratory strain of a common virus, making the microbes collect exotic materials - cobalt oxide and gold. And because these viruses are negatively charged, they can be complexed between oppositely charged polymers to form thin, flexible sheets. The result? A dense, virus-loaded film that serves as an anode.

A lack of energy density - meaning the amount of charge a battery of a given size can usefully carry - is what has hampered development of electric cars, since existing batteries are generally too heavy and too weak to compete with gasoline as an energy source. "The nanoscale materials we've made supply two to three times the electrical energy for their mass or volume, compared to previous materials," the team reported.

A report on the work will appear in the April 7 issue of Science.

A New Membrane for Cheaper Fuel Cells

Fuel cells still cost too much to be a viable alternative for internal combustion engines in cars -- they require expensive materials and are difficult to make. Now, a new, simple-to-produce material boosts the performance of fuel cells many times -- and could be a major step toward making them affordable. The University of North Carolina at Chapel Hill researchers who developed the new material say it can "dramatically outperform" the material now used to form fuel-cell membranes.

Proton-exchange membranes are used in fuel cells to sort protons and electrons, by allowing the protons to pass through them from one electrode to the other, while blocking electrons and forcing them to travel between electrodes via an external circuit, powering a motor or other electronic device along the way.

The researchers say the new membrane conducts protons nearly three times as well as the currently used material, significantly improving power density. Also, unlike the current material, the new membrane can be easily molded into patterns to increase its surface area. By increasing the area by up to 60 percent, the researchers have further doubled the power density of a fuel cell. Joseph DeSimone, main author of the work, thinks the membrane's surface area can be increased 20 to 40 times by using different patterns, increasing the power density proportionately. Such improvements in power density mean that a much smaller fuel cell could provide adequate power for a vehicle. The material is also easier to work with, which should reduce manufacturing costs. It begins as a liquid that can be poured over a patterned mold, something that's not possible with the material now primarily used in membranes, a fluorinated polymer called Nafion made by DuPont, which is solid at room temperature.

DeSimone says that a clearer idea of potential cost savings from their new material should be available within six months. And he expects that fuel cells using the membrane could be in production within two to three years.

Study sets benchmark properties for popular conducting plastic

Steadily increasing the length of a purified conducting polymer vastly improves its ability to conduct electricity, report researchers at Carnegie Mellon University, whose work appeared in the Journal of the American Chemical Society. Their study of regioregular polythiophenes (RRPs) establishes benchmark properties for these materials that suggest how to optimize their use for a new generation of diverse materials, including solar panels, transistors in radio frequency identification tags, and light-weight, flexible, organic light-emitting displays.
"We found that by growing very pure, single RRP chains made of uniform small units, we dramatically increased the ability of these polymers to conduct electricity," said Richard D. McCullough, who initially discovered RRPs in 1992. "This work establishes basic properties that researchers everywhere need to know to create new, better conducting plastics. In fact, designing materials based on these results could completely revolutionize the printable electronics industry."

"Our results are very significant, since they cast new light on the mechanism by which polymers conduct electricity," Unlike plastics that insulate, or prevent, the flow of electrical charges, conducting plastics actually facilitate current through their nanostructure. Conducting plastics are the subject of intense research, given that they could offer light-weight, flexible, energy-saving alternatives for materials used in solar panels and screen displays. And because they can be dissolved in solution, affixed to a variety of templates like silicon and manufactured on an industrial scale, RRPs are considered among the most promising conducting plastics in nanotech research today.
"Our tests showed that highly uniform RRPs self-assemble into well-defined elongated aggregates called nanofibrils, which stack one against the other. About 5,000 of these nanofibrils would fit side by side in the width of a human hair. The presence of these well-defined structures allowed us for the first time to make a connection between the size of polymer molecules, the type of structure they form and the ease with which current can move through nanofibril aggregates."
"We made the key discovery that mobility -- how easily electrons move -- increases exponentially as the width of a nanofibril increases,". Each rope-like nanofibril actually is a stack of RRP molecules, so the longer these molecules, the wider the nanofibril and the faster the electrical conductivity. In this way, electricity moves preferably perpendicular through the rows of naturally aligned nanofibrils. Conductivity increases with the length of an RRP molecule -- and hence the width of each nanofibril -- because it takes less time for a charge carrier to cross through wider nanofibrils than narrower ones. (Charge carriers are unbound particles that carry an electric charge through a molecular structure). All this can be tied to the fact that a charge carrier that enters a short molecule disrupts its energetic environment considerably more than if that same charge carrier enters a long molecule. This energetic hurdle, called reorganization energy, thus slows the movement of charge carriers that move from short molecule to short molecule. The energetic hurdle is lower for a long molecule, which can absorb changes to its electrical environment more easily. This phenomenon could be one of the reasons why charge carriers jump more quickly from long molecule to long molecule.

IBM Scientists Develop New Way To Explore And Control Atom-scale Magnetism

IBM scientists have developed a powerful new technique for exploring and controlling magnetism at its fundamental atomic level.

The new method promises to be an important tool in the quest not only to understand the operation of future computer circuit and data-storage elements as they shrink toward atomic dimensions, but also to lay the foundation for new materials and computing devices that leverage atom-scale magnetic phenomena. "We have developed a window into the atomic heart of magnetism," said Andreas Heinrich, at IBM's Almaden Research Center "We can now position atoms and then measure and control their magnetic interactions within precisely designed structures."

"This kind of exploratory research is essential for the long-term future of the computer industry," said Gianluca Bona, manager of science and technology at IBM Almaden. "Sometime in the next couple of decades, it will be impossibly difficult to continue improving transistors and other traditional microelectronic circuit elements by simply shrinking them. We will then need alternative structures and, perhaps, altogether different ways of computing. Techniques like this can help us gain the knowledge needed to create those alternatives." In addition to exploring the basic properties of magnetic materials, the IBM researchers expect to use this new technique in the future to:

- Explore the limits of magnetic data storage, by engineering the energy required to flip the collective orientation of a small number of magnetically coupled atoms.
- Determine the feasibility of spin-based wires and a spin version of the molecular-motion cascade, the group's 2002 achievement that included an arrangement of molecules that formed a working computer circuit some 260,000 times smaller than its conventional design in silicon (or about 50 years of circuit-shrinking at Moore's Law pace).
- Investigate how engineered spin interactions could be applied to quantum information systems, such as quantum computers.

The new method, called spin-excitation spectroscopy, uses IBM's special low-temperature scanning tunneling microscope designed for use with a broad range of magnetic fields up to 140,000 times stronger than the earth's. The researchers first move atoms into position and then measure the interactions between their atomic spins, which are the fundamental sources of magnetism. In their experiments, the IBM researchers created chains of up to 10 manganese atoms atop an extremely thin electrically insulating surface and measured how the magnetic properties changed as each new atom was added. They found that chains with an even number of atoms had no net magnetism, while chains with an odd number of atoms showed net magnetism.

Life Sciences

New 3D inside imaging for endoscopic surgery

A tiny, sensitive, ultrasound probe which gives 3D images from inside the body during endoscopic surgery is ready to begin human trials.

Researchers at Duke's Pratt School of Engineering in the US have used the device to image the beating hearts of dogs. The engineers said their demonstration showed that the probes could give surgeons a better view during human endoscopic surgeries, in which operations are performed through tiny "keyhole" incisions. If the probes prove beneficial in human testing, the advance might lead to more precise and safer endoscopic surgeries, said the Duke engineers.

"Surgeons now use optical endoscopes or two-dimensional ultrasound when conducting minimally invasive surgery," said lead engineer Stephen Smith, a professor of biomedical engineering at the Pratt School. "With our scanner, doctors could see the target lesion or a portion of an organ in a real-time three-dimensional scan," Smith said. "They would have the option of viewing the tissue in three perpendicular cross-sectional slices simultaneously or in the same way a camera would see it, except that a camera can't see through blood and tissue."
The technology has yet to be tested in human patients, but its success in dogs makes it ready for clinical trials, according to the researchers.
Duke developed the first 3D ultrasound scanner in 1987 for imaging the heart from outside the body. As technology enabled ever-smaller ultrasound arrays, the researchers engineered probes that could fit inside catheters threaded through blood vessels to image the vasculature and heart from the inside out.

The current advance relies on 500 tiny cables and sensors packed into a tube 12 millimetres in diameter, the size required to fit into surgical instruments, called trocars, that surgeons use to allow easy exchange of laparoscopic tools. By comparison, most two-dimensional ultrasound probes use just 64 cables.Each cable carries electrical signals from the scanner to the sensors at the tip of the tube, which in turn send pulses of acoustic waves into the surrounding tissue, Smith said. The sensors then pick up the returning echoes and relay them back to the scanner where they produce an image of the moving tissue or organ. The scanner uses parallel processing to listen to echoes of each pulse in 16 directions at once.

The laparoscopic ultrasound probes have so far been applied only to heart imaging, in which they may be particularly useful for monitoring heart function during minimally invasive cardiac surgery, Smith said. Current methods often monitor the heart with a 2D ultrasound endoscope probe down the throat, a method that requires general anaesthesia. Similar 3D ultrasound devices also hold promise for minimally invasive abdominal and brain surgery applications, Smith said.

Researchers get neurons and silicon talking

European researchers have created an interface between mammalian neurons and silicon chips. The development is a crucial first step in the development of advanced technologies that combine silicon circuits with a mammal's nervous system.

The ultimate applications are potentially limitless. In the long term it will possibly enable the creation of very sophisticated neural prostheses to combat neurological disorders. What's more, it could allow the creation of organic computers that use living neurons as their CPU.

Those applications are potentially decades away, but in the much nearer term the new technology could enable very advanced and sophisticated drug screening systems for the pharmaceutical industry.

"Pharmaceutical companies could use the chip to test the effect of drugs on neurons, to quickly discover promising avenues of research," says Professor Stefano Vassanelli, a molecular biologist with the University of Padua in Italy, and one of the partners in the NACHIP project, funded under the European Commission's Future and Emerging Technologies initiative of the IST programme.

NACHIP's core achievement was to develop a working interface between the living tissue of individual neurons and the inorganic compounds of silicon chips. It was a difficult task.

"We had a lot of problems to overcome," says Vassanelli. "And we attacked the problems using two major strategies, through the semiconductor technology and the biology."

With the help of German microchip company Infineon, NACHIP placed 16,384 transistors and hundreds of capacitors on a chip just 1mm squared in size. The group had to find appropriate materials and refine the topology of the chip to make the connection with neurons possible.

Biologically NACHIP uses special proteins found in the brain to essentially glue the neurons to the chip. These proteins act as more than a simple adhesive, however. "They also provided the link between ionic channels of the neurons and semiconductor material in a way that neural electrical signals could be passed to the silicon chip," says Vassanelli.

Once there, that signal can be recorded using the chip's transistors. What's more, the neurons can also be stimulated through the capacitors. This is what enables the two-way communications.

The project tested the device by stimulating the neurons and recording which ones fired using standard neuroscience techniques while tracking the signals coming from the chip.

The development of the interface and chip are crucial for this new technology, but problems remain. "Right now, we need to refine the way we stimulate the neurons, to avoid damaging them," says Vassanelli.

That's one of the problems the team hopes to tackle in a future project. Right now a proposal has been prepared which could tackle this and many other problems, including how to communicate with the neurons using genes.

"Genes are where memory come from, and without them you have no memory or computation. We want to explore a way to use genes to control the neuro-chip," says Vassanelli.

If NACHIP took the first crucial step towards a neuron-powered CPU, future work will pave the way for a genetically-powered hard disk.

"Europe is very well placed in this field of research, because it is essentially a multidisciplinary field, and we have multidisciplinary teams working on it," says Vassanelli. "We also have the infrastructure with institutes like the Max Planck Institute for Biochemistry in Martinsried, which is one of the world leaders in the field. Europe should be very proud of these resources. It gives us access to equipment and expertise that would be very hard to replicate elsewhere."

Cell Division can be Reversible

Gary J. Gorbsky, Ph.D., a scientist with the Oklahoma Medical Research Foundation, has found a way to reverse the process of cell division. The discovery could have important implications for the treatment of cancer, birth defects and numerous other diseases and disorders.

Gorbsky's findings appear in the April 13 issue of the journal Nature.

"No one has gotten the cell cycle to go backwards before now," said Gorbsky. "This shows that certain events in the cell cycle that have long been assumed irreversible may, in fact, be reversible." Cell division occurs millions of times each day in the human body and is essential to life itself. In the lab, Gorbsky and his OMRF colleagues were able to control the protein responsible for the division process, interrupt and reverse the event, sending duplicate chromosomes back to the center of the original cell, an event once thought impossible.
"Our studies indicate that the factors pointing cells toward division can be turned and even reversed," Gorbsky said. "If we wait too long, however, it doesn't work, so we know that there are multiple regulators in the cell division cycle. Now we will begin to study the triggers that set these events in motion."

The findings may prove important to controlling the development and metastasis of certain cancers. It also holds promise for the prevention and treatment of birth defects and a wide variety of other conditions.

New device could cut chemotherapy deaths

A new method of delivering chemotherapy to cancer patients without incurring side effects such as hair loss and vomiting is being developed

The method, produced at the University of Bath, involves using tiny fibres and beads soaked in the chemotherapy drug which are then implanted into the cancerous area in the patient's body.

These fibres are bio-degradable and compatible with body tissue, which means they would not be rejected by the patient's body. They gradually turn from solid to liquid, releasing a regular flow of the chemotherapy chemical into the cancer site, and a much lower dose to the rest of the body. This is a more localised way of killing cancer cells than the current method of injecting the chemical into a cancer sufferer's vein so that it is carried around the body.
As well as reducing the side-effects, the new drug delivery vehicle, known as Fibrasorb, could also cut the numbers of patients who die from the effects of chemotherapy because they need such high doses to tackle their cancer.

The Fibrasorb technology is a flexible fully resorbable device that can be formulated as a bead, a fibre or mesh, or as a tube put into the body which leads outside the body and through which drugs can be fed.

The method, developed by Dr Semali Perera, over the past few years, has successfully gone through preliminary laboratory trials. The first clinical trials on volunteer patients could begin in the next few years and, if successful, the technology could be put into general use.

"The new fibres and beads could cut out some side-effects entirely, including nausea and vomiting, and could reduce the number of people who die each year.