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The Latest Technology Research News

TRN's Top Picks

Technology Research Advances of 2004

Each year sees more researchers at work and more research papers published than the last -- the volume of scientific and technological research has doubled every decade for the past three centuries.

The profusion of technology research in 2004 includes notable advances in biotechnology, communications, computing, engineering, energy, security, nanotechnology, applied physics and the Internet.

Biotechnology

Biotechnology researchers use a wide range of natural forces and clever tools to bend molecules to useful ends.

This includes biomolecular engineering -- manipulating DNA and biological molecules like proteins to carry out computing, to sense other molecules, and to construct materials molecule by molecule. One of the most significant research advances of the year was the development of a DNA device that senses and attacks cancer cells by researchers at the Weizmann Institute in Israel.

Biotechnology tools include microfluidic devices, laser tweezers and sensors used for engineering biological molecules, medical diagnostics, and security. Biotechnology tools advances include a nanowire-based biochip developed by Harvard University researchers that detects single viruses , and a biochip developed by University of Texas researchers that uses water droplets as tiny test tubes.

Communications

This year's communications research saw faster and smaller lasers and light-emitting diodes for generating light pulses, and more efficient and more versatile optical fibers and photonic crystal devices for channeling light. Faster signals and switches translates to higher communications rates.

Photonic crystal research continued to heat up, highlighted by two research teams -- MIT and Kyoto University -- that developed three-dimensional photonic crystal devices that emit as well as channel light. Cornell University researchers used more conventional light-channeling devices to create a silicon switch that allows one light beam to control another.

Computer chips

Two roads promise to take computer chips past the end of today's silicon technology. One involves new materials and processing techniques and the other heralds entirely new types of chips.

Alternative approaches include efforts to build computer chips from nanotubes and individual molecules. Nanotube and nanowire-based chip research moved this year from the level of transistors and simple logic gates to that of entire chip architectures. Hewlett-Packard Laboratories researchers developed a highly redundant, highly fault-tolerant chip design for their nanowire logic circuits , and researchers at Duke University developed a software program for designing computer chips made from DNA-assembled carbon nanotubes.

Researchers from the French National Center for Scientific Research (CNRS) and University College London in England looked further into the future to outline a scheme for designing whole logic gates within individual molecules. The scheme is

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Letter to readers

Briefs:
Alcohol fuel cell goes micro
LED array turned into touch button
Coated nanotubes make biosensors
Gestures control true 3D display
Atom demo fixes quantum errors
Virtual turntable simplifies sharing
Molecular motor goes both ways
Solar cell teams plastic and carbon
DNA makes and breaks particle clumps
Sapphire steps shape nanotubes arrays

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based on the way electrons move around the molecules.

Computer interfaces

Making computers easier to use is a broad, long-term effort that includes improving today's screen-based interfaces and extending computers' sensing ability so they can more naturally interact with humans.

Researchers from Microsoft Research, Microsoft Research Asia, and Tsinghua University in China showed that surfing the Net using a handheld device can be improved by allowing the user to zoom in on relevant content and collapse irrelevant content with single pen strokes.

Researchers at Sony Corporation developed a control knob that the user can reshape to change functions, and are ultimately aiming for an input device that users can mold like clay.

And scientists from the NASA Ames Research Center developed speech recognition technology that allows users to speak silently. The scheme uses throat nerve activity rather than acoustics to glean information about what a person is saying.

It became readily apparent this year that projectors have the potential to change the way we view display technologies. Researchers from Mitsubishi Electric Research Labs developed a combination handheld projector and radio frequency identification tag reader that lights up tagged objects, projects information about them and serves as a computer screen.

And researchers from the University of Cambridge in England and Light Blue Optics Ltd. advanced efforts to build projectors into everything from laptop computers to cell phones using a holographic technology.

Engineering

Engineering research is about devising and improving methods for constructing devices and, ultimately, building better ones.

Advances in engineering research this year include a Massachusetts Institute of Technology process that allows optical fiber to contain tiny metal and semiconductor wires. The method could lead to extremely inexpensive electrical components.

An array of small pressure sensors on a flexible sheet from University of Tokyo researchers promises to lead to smart rugs and robot skin.

And North Carolina State University and University of Utah researchers showed that it was possible to evolve the ability to play Capture the Flag in a simulation using artificial neural networks and then download the smarts into real mobile robots.

Energy

Energy research ranges from finding ways to power microscopic machines to developing renewable energy sources for global consumption. Many research teams are working on solar and hydrogen energy systems, and there have been several significant developments this year.

Scientists from Toin University of Yokohama in Japan built a single, compact device that converts solar energy to electricity and also stores the electricity. This is an improvement from today's combination of solar energy devices that harvest the energy from light and batteries that store the energy. The device is also relatively efficient at harvesting ambient light; it could eventually allow people to recharge cell phones, for instance, using indoor light.

Los Alamos National Laboratory researchers found a way to double a solar cell's potential energy production by using the energy of a single photon to move two electrons rather than just one, and researchers from Lawrence Berkeley National Laboratory, the University of California, and the Massachusetts Institute of Technology engineered a single material that is capable of capturing more than 50 percent of the sun's energy from across the solar spectrum.

On the fuel cell front, University of Wisconsin at Madison researchers found a way to use carbon monoxide, a fuel cell waste product that ordinarily degrades cells, to

produce more energy. Researchers from the University of Minnesota and the University of Patras in Greece devised a way to extract hydrogen directly from ethanol, which is produced by converting biomass like cornstarch to sugar, then fermenting the sugar.

Information

Information research falls into two categories: data access and retrieval, and data processing and presentation. Data access and retrieval research is focused on making database and Internet searches faster, easier and more accurate. Data processing and presentation research involves turning data into manageable and understandable information.

On the data access and retrieval front, Massachusetts Institute of Technology and Cornell University researchers developed software that picks up the topic structure of whole documents to generate more accurate automatic summaries.

Researchers from the University of Wales, Robert Gordon University in Scotland, and the University of Manchester in England advanced data processing and presentation with a robot scientist that can devise a theory, come up with experiments to test the theory, carry out the experiments, and interpret the results.

Security

This year brought a pair of security research developments that made it apparent that quantum cryptography, unlike quantum computing, is within a few years of prime time. Quantum cryptography has the potential to provide perfectly secure communications.

On April 21, researchers from the University of Vienna in Austria, ARC Seibersdorf Research GmbH in Austria, the University of Munich in Germany, and the Austrian Academy of Sciences transferred a secret encryption key from Vienna City Hall to a Bank Austria Creditanstalt office a few blocks away using an entanglement-based form of quantum cryptography.

And BBN Technologies, Harvard University and Boston University researchers built a six-node quantum cryptography network designed to operate continuously to provide a way to exchange secure keys between BBN, Harvard and Boston University. Previous quantum cryptography systems sported only point-to-point connections.

Nanotechnology

The burgeoning field of nanotechnology -- the quest to build devices and materials from infinitesimal metal and semiconductor particles and even individual molecules -- continued its fast pace this year.

A pair of significant developments each had researchers taking DNA for a walk. Scientists at Duke University and the University of Oxford in England put together a series of DNA stations that can automatically pass a DNA fragment from one to the next. California Institute of Technology researchers improved the gait of a bipedal DNA walker originally designed by researchers at New York University from shuffling, with one leg always trailing the other, to leg-over-leg walking.

Nanotubes continue to be a promising nanotech building block. Researchers from the Japanese National Institute of Advanced Industrial Science and Technology (AIST) found a relatively simple way to manufacture tall, dense, vertically-aligned stands of pure nanotubes. Nanotubes produced using the method are orderly and pure enough for use in medical implants as well as electronics.

Physics

Physics contributes to technology in many ways. A more detailed knowledge of matter and energy can improve many tasks, from storing data to making better lasers. Tapping the weird effects of quantum phenomena makes for better micromachine designs and has the potential to produce fantastically powerful computers.

The year saw several advances in timekeeping. Researchers from the National Physical Laboratory in England made a prototype atomic clock that divides time into finer slices because it uses high-frequency optical radiation, or lightwaves, rather than

the usual microwave radiation. The devices could lead to a more accurate definition of time, which would improve global positioning systems, make space exploration more accurate, and more accurately test the laws of physics.

Scientists at the National Institute of Standards and Technology (NIST), keepers of official U.S. time, developed a tiny atomic clock that promises to bring precision timing down to the level of handheld devices.

Researchers at Stanford University devised a scheme for storing light pulses under ordinary conditions using photonic crystal. The technique could be used to make blazingly fast all-optical computer chips, quantum computers and quantum communications systems.

Quantum computing advances this year include a demonstration of five-photon entanglement by researchers from the University of Science and Technology of China, the University of Innsbruck in Austria, and the University of Heidelberg in Germany. Five-photon entanglement could be used to make quantum networks and quantum error correction schemes, which are necessary for practical quantum computers.

Meanwhile, researchers from the Massachusetts Institute of Technology and the National Atomic Energy Commission in Argentina developed a quantum random number generator that greatly reduces the ordinarily overwhelming complexity of quantum randomness while still producing random results. A quantum random number generator would improve quantum error correction schemes and quantum cryptography.

Data storage

Data storage research involves finding new materials and recording methods that will allow more information to be stored per square centimeter, information to be stored in retrieved more quickly, and storage devices to better withstand forces like heat and radiation. Experimental storage devices include carbon nanotube memory elements, light-sensitive plastic films and stacks of two-dimensional holograms.

Boston University researchers made a minuscule mechanical memory cell from a silicon beam clamped at both ends. The beam is so small that it vibrates millions of times a second, which means that it could switch on and off at speeds comparable to electronic memory chips, but would be able to retain data with the power off and in the presence of radiation.

The Internet

Research about the Internet falls into three categories: Web software, Internet infrastructure, and the overall structure of the Internet. In addition to finding better ways to browse and search the Internet, researchers are examining details of the network's structure to find ways to improve its stability and performance.

Researchers from the University of Michigan developed the Small-World Instant Messaging system (SWIM), which extends instant messaging systems by identifying expertise and routing queries accordingly.

Researchers from Cornell University and the Internet Archive devised a way to measure users' reactions to an item description: a "batting average" of the number of users who go on to download the item divided by the number of users who read the description.

And a researcher from the Max Planck Institute for the Physics of Complex Systems in Germany showed that it might be possible to suppress cascade failures triggered by attacks on large network nodes by shutting down peripheral nodes, much like a forest fire can be controlled by setting small containment fires.