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Technology Research News
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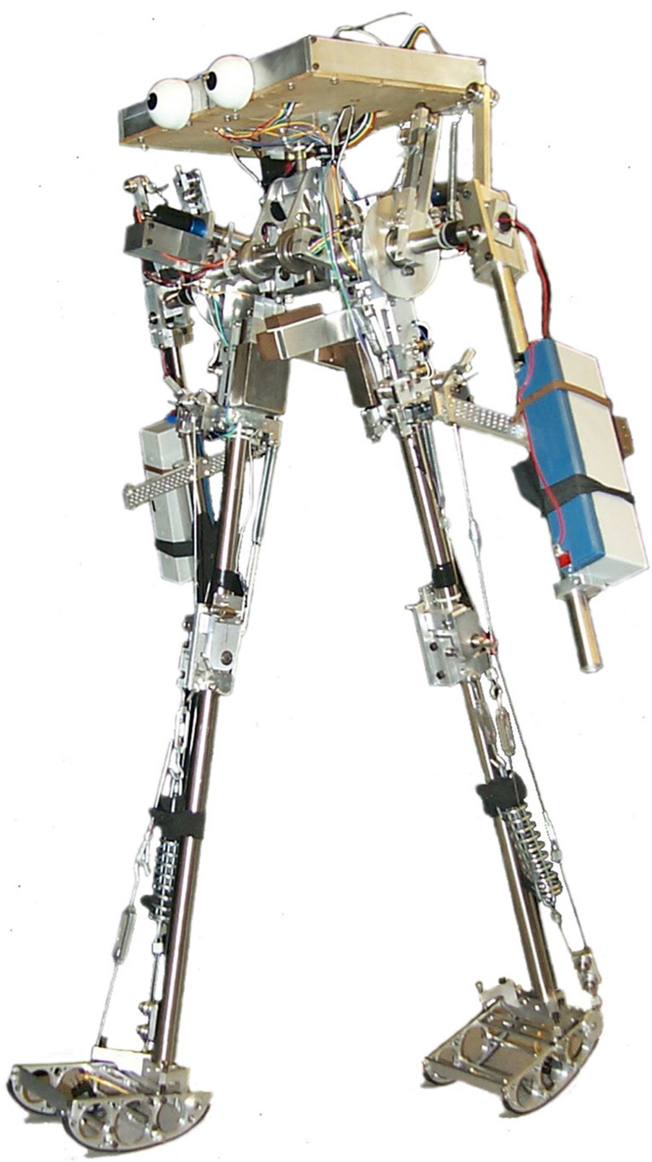
Humanoid robots walk naturally

A trio of skeleton-like robots shows that walking is more a matter of bones than brains or brawn.



Software gives descriptive directions

Teaching computers about landmarks makes for better automated directions.

Impact Assessment

Roadside Eye Catchers

Rod arrays focus sound

The right arrangement of rods makes a lens for sound waves.

... and more

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Ask a person for directions and you are likely to hear about landmarks. Computer-generated directions, on the other hand, can give you precise distances but rarely include landmarks. Given that people prefer to be told to turn left at the elevators rather than being told to walk east for 50 paces, route planning software has room for improvement. A system that has a sense of place is a big step in the right direction.
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Springs simplify micromirror arrays
Taking the twinkle out of stars allows astronomers to see them better. Such sharpening is also important for optical applications ranging from retinal imaging to spy satellites. Arrays of tiny movable mirrors make it possible to restore distorted light waves. A control system based on the stiffness of springs promises to make those arrays cheaper, smaller and tougher.
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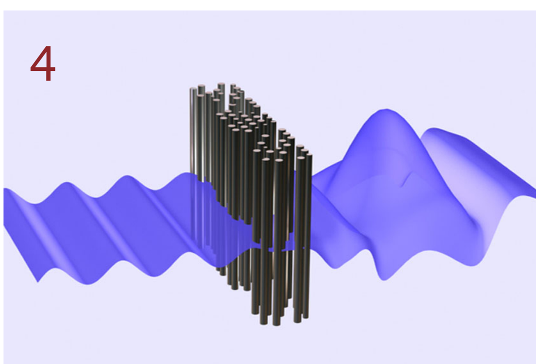


Cover image source: Steven H. Collins

fact

A contracting muscle is at most 25 percent, but the overall efficiency of the human body during running is 40 to 50 percent. The efficiency boost is due to spring-like tendons recycling mechanical energy by storing it during a footfall and releasing it when the foot pushes off. Tendons are efficient at storing mechanical energy — they return about 93 percent of the energy it takes to stretch them.

quote

"It is not the highly accurate, stationery, single-task machine with minimal sensibilities that is needed anymore, as in typical industrial applications. Rather, it is a new kind of robot, richly equipped with multi-model sensing, a high-level dexterity, compliance for safe operation, energy efficiency, and mobility."

- Stefan Schaal, University of Southern California

Briefs

Process Yields Semiconductor Foam

Researchers from Wayne State University have made crystalline aerogels — new semiconductor materials that are very porous, giving them very high surface areas.

Unlike conventional aerogels, the researchers' materials are crystalline. They are made from cadmium sulfide, zinc sulfide, lead sulfide and cadmium selenium.

The materials contains pores that average 15 to 45 nanometers, which gives the materials useful optical and electrical properties and also allows for rapid transport of gas. It has traditionally been difficult to prepare materials with pore sizes in this range.

The materials could eventually be used as chemical and biological sensors, solar cells and photocatalysts, according to the researchers. Photocatalysts trigger chemical reactions in the presence of light.

The researchers constructed the materials by first making semiconductor nanocrystals. They mixed the nanocrystals with an organic molecule that links the nanoparticles to form an air-filled gel. They dried the gel using highly compressed, or supercritical, carbon dioxide. The materials retain the electrical and optical properties of the nanocrystals rather than those of the bulk materials.

It will be 10 to 20 years before the researchers' materials can be used practically; the general assembly method could be applied using other materials sooner, however, according to the researchers. The work appeared in the January 21, 2005 issue of *Science*.

Rod Arrays Focus Sound

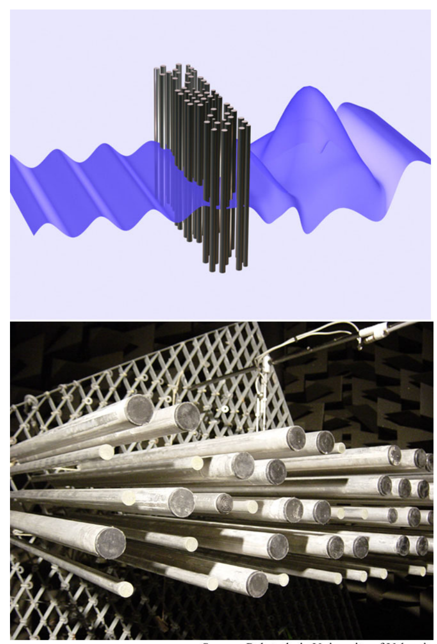
Researchers from the Polytechnic University of Valencia in Spain have produced a pair of flat lenses that control soundwaves.

The lenses could eventually be used in acoustic microscopes that use sound waves to examine the internal composition of objects and materials. They could also be used in non-invasive surgical tools like lithotripsy apparatus, according to the researchers. Lithotripsy is a medical procedure that uses ultrasound to pulverize kidney stones.

The flat acoustic lenses are made of irregularly spaced arrays of aluminum cylinders. The design was produced by a tool that combines multiple scattering theory and a genetic algorithm, and is optimized to concentrate sound waves at a focal point.

Multiple scattering theory is the mathematical framework for modeling the way waves moved through inhomogenous substances. Genetic algorithms take a design through many random iterations by randomly combining the best designs of a set to produce a new design.

The researchers have a pair of prototype lens designs. Both use aluminum cylinders that are one, two and three centimeters in diameter and two meters long. One design has five layers and the other nine layers. The cylinders occupy some of the points in a hexagonal lattice, creating a pattern determined by the genetic algorithm. The lenses are considered flat because the cylinders are confined to a rectangular area. Both amplify sound up to 6.4 decibels at a focal point.



Source: Polytechnic University of Valencia

This arrangement of aluminum rods concentrates sound waves; the graphic shows how the sound waves are affected by the rods.

The researchers are also working on an electromagnetic counterpart to the acoustic lens, dubbed Scattering Optical Elements.

The acoustic method could find practical application in two to five years, according to the researchers. The work appeared in the January 1, 2005 issue of *Applied Physics Letters*.

Metal Atoms Make Silicon Magnetic

Researchers and manufactures routinely dope, or add impurities too, semiconductors like silicon to give the material specific electrical properties. Researchers are also working out ways to dope silicon to control its magnetic properties.

Devices made from magnetic semiconductors can make use of the spin of the electron in addition to its charge. These spintronics devices are potentially faster and consume less power than today' electronics.

Researchers from the State University of New York at Albany have found a way to make silicon ferromagnetic at room temperature. Ferromagnetic materials respond strongly to magnetic fields and remain magnetic after an external magnetic field has been removed. This opens the door to developing spintronics devices using the material of computer chips, which is easily manufactured using existing facilities.

The researchers implanted silicon with manganese ions to make a material that retains its ferromagnetic properties at temperatures as high as 127 degrees Celsius. The researchers doped the silicon at two concentrations of manganese: 0.1 percent and 0.8 percent. They found that the level of magnetism depends on the concentration of manganese, the temperature, and whether the silicon has been doped to be a positive or negative charge carrier.

The researchers' next steps are to more fully understand the electronic and physical structure of the material in order to determine the origin of the ferromagnetism.

The device could be ready for practical use in five to ten years, according to the researchers. The work appeared in the January 4, 2005 issue of *Physical Review B*.

TRN

Speech Software Makes Concept Maps

As anyone who has been responsible for taking notes at a meeting can attest, paying attention to note-taking takes away from listening to or participating in a brainstorming session.

Researchers from the University of Duisburg-Essen and the University of Leipzig in Germany have devised a tool that uses speech recognition software and a database of word associations to automatically generate a map of concepts and associated terms as they are addressed in a discussion.

The tool, dubbed SemanticTalk, could eventually be used to support and document meeting activity like brainstorming, and produce raw concept material for tasks like Web site engineering, software development and product marketing, according to the researchers.

The researchers' prototype works in German. It uses a continuous speech recognition engine to collect keywords from a conversation and a large database of German terms and weighted associations between them to organize the material. The prototype includes terms from everyday speech and terminology related to business and economics.

The system displays results in real-time, providing participants with an on-the-fly visualization of the topics and ideas under discussion. Spoken terms appear on screen in one color and related terms in another. Related terms are linked by lines, and the entire set of words is presented as a logical map.

The next step is improving the ability of the system to deal with topic shifts, according to the researchers.

The system could be ready for commercial use in three to five years, according to the researchers. They presented the work at the Intelligent User Interfaces Conference (IUI 2005) held January 9 to 12, 2005 in San Diego.

TRN

Tiny Transistors Sniff Chemicals

One reason many teams of researchers are working to make electrical components from organic, or carbon-based, materials is these materials are inexpensive to manufacture.

Researchers from the University of Texas at Austin have found that the chemical sensing abilities of infinitesimally small transistors made from thin films of the organic crystal pentacene are quite different from those of larger transistors made from the same materials.

Electrical current flows from the source electrode of a transistor through its channel to the drain electrode. A transistor can be used as a sensor because the electrical flow can be affected by different conditions, including chemicals bonding to the semiconductor channel.

Nanoscale transistors make for more sensitive sensors than larger transistors because a change in electrical response that is due to the presence of a few molecules of a target substances is large enough to be detectable. The researchers tested transistors that contained channel lengths ranging from 20 to 36,000 nanometers. A nanometer is one millionth of a millimeter.

The researchers found that the direction and amplitude, or strength, of sensing responses correlate to the length of the transistor channel and grain size of the pentacene crystals that make up the thin film.

Sensors made from the thin-film transistors have the potential to be very inexpensive. They could be manufactured using ink-jet printers.

The researchers are working on better understanding the interaction between various substances and the organic semiconductor layer, finding optimal semiconductor layers for various substances, and improving the durability of the organic semiconductor.

Such nanoscale sensors could be used practically within five years, according to the researchers. The work appeared in the December 27, 2004 issue of *Applied Physics Letters*.

TRN

Plastic Changes Color in Heat

Materials that change color depending on the temperature are potentially very useful. They can be used in sensors, adaptive camouflage, passive environmental controls and changeable paint.

Researchers from Helsinki University of Technology and the University of Helsinki in Finland, the Technical Research Centre of Finland and the University of Groningen in the Netherlands have engineered a plastic that loses its color when heated.

The material is green at room temperature but loses its color when heated beyond 125 degrees Celsius. It could eventually be used to produce relatively inexpensive temperature-based paint.

The material consists of two types of polymers that, because they repel each other, automatically assemble into alternating layers. The layer structure repeats every 117 nanometers, which causes the material to reflect light that has a wavelength of 530 nanometers.

Heating the material breaks hydrogen bonds, which releases stretched-out polymer molecules, allowing them to coil up. This shortens the polymer layers, which causes the material to reflect light that has a wavelength of 370 nanometers. The change in the size lightwave the material reflects is relatively large over a relatively narrow temperature range of about 10 degrees Celsius, according to the researchers.

The materials could be used in practical applications in two to five years, according to the researchers. The work appeared in the November 28, 2004 issue of *Nature Materials*.

TRN

Light Writes Data in Electrons

Many research teams are working on spintronics — controlling the spin of electrons so they can be used to represent information. Electrons have two possible spin directions, somewhat like a top that can spin clockwise or counterclockwise.

These spin directions can be used to represent the 1s and 0s of computer information in standard classical computers. Single electron spins can also be used as quantum bits, the basic logic unit of quantum computers. Quantum computers have the potential to solve certain types of problems many orders of magnitude faster than classical computers.

Key to using spin to represent information is being able to set electron spin, store the electrons, and read the electrons' spins.

Researchers at the Technical University of Munich in Germany have advanced the field with an optically programmable spin memory device that writes data as electron spins using lasers, stores the electrons in bits of semiconductor dubbed quantum dots, and reads spin information by applying a voltage to the quantum dots to convert the electrons to photons.

The researchers have shown that it is possible to store spins in their device for longer than 20 milliseconds, which is enough time to carry out computations on the information.

The researchers' prototype of gallium indium arsenide quantum dots works in a magnetic field of 4 tesla and a temperature near absolute zero. A tesla is about 10 times the strength of a kitchen magnet.

Because the spins are programmed optically, many spin systems can be programmed at once, according to the researchers. The researchers are working on ways to measure individual spins separately.

The optically-programmed spin method could be used practically in classical computers in five to ten years, according to the researchers. Most researchers agree that quantum computers will not be practical for one or two decades. The work appeared in the November 4, 2004 issue of *Nature*.

Stories

Humanoid Robots Walk Naturally

By Kimberly Patch, Technology Research News

There's a reason most movie robots have wheels in place of legs or are powered by an embedded human. Making machines walk on two legs is exceedingly difficult.

There are at least four major challenges — working out the movements that make up a practical bipedal step, finding ways to handle uneven terrain and unexpected jostling, making the system energy-efficient, and giving the system the ability to move away when pushed, which is important for safety, especially in robots designed for use around people.

In short, when it comes to robots, walking down the street is not like rolling off a log.

Researchers from Delft University in the Netherlands, Cornell University, and the Massachusetts Institute of Technology have moved robot bipedal motion a large step forward with three similar robots that walk like humans.

The three robots tap passive-dynamic walker technology, a field begun with the 1988 discovery by Tad McGeer that a skeleton can very nearly walk on its own. Passive-dynamic walkers are simple mechanical devices made from rigid parts connected by joints, and the skeleton-like structures can walk by themselves down a slope. Gravity provides all the power they need, and their movements look much like human walking motions. The three new robots walk on level ground with small active power sources substituting for gravity.

The concept is analogous to the Wright brother's approach of perfecting glider flight and then attaching an engine to the airplane, according to the researchers.

The passive-dynamic walker robots use less energy to move and their walking motions look more human than existing bipedal robots, said Andy Ruina, a professor of theoretical and applied mechanics and mechanical and aerospace engineering at Cornell. The big difference in the passive-dynamic design is instead of controlling all joint movements all the time, most of the joints are left to swing freely, he said.

This line of research promises to improve our understanding of how people walk, said Ruina. "This general understanding should assist in the development of analysis and correction of various human disabilities," he said.

Better understanding, in turn, also promises to improve robot technology, especially along the lines of efficiency and safety. Passive-dynamic walker robots could eventually be used to assist humans in many contexts, including search and rescue efforts, hazardous environments, schools, hospitals, and homes.

The potential uses include prosthetics and rehabilitation robots, said Stephen Collins, one of the Cornell researchers who is now at the University of Michigan. Collins is currently working on a foot prosthesis prototype that stems from the robotics work.

The Cornell robot stands about as tall as a small adult and weighs 13 kilograms, or a little less than 29 pounds, and is the most energy-efficient of the robots. The child-size Delft robot weighs 8 kilograms, or a little less than 18 pounds, and uses pneumatics. The MIT robot stands 17 inches tall, weighs 2.75 kilograms, or about six pounds, and uses a learning algorithm to constantly adapt to changing terrain. The Cornell and Delft robots use a single pivoting joint for hips. The MIT robot does not have knees.

The Cornell robot was designed to be as energy-efficient as possible, and is nearly as efficient as a human. It requires three watts of energy to walk; including electronics, it consumes 11 watts.

Source: Steven H. Collins

These robots -- left to right from Delft University of Technology, the Massachusetts Institute of Technology and Cornell University -- are energy-efficient because their skeleton-like structures handle most of the mechanics of walking.

The most significant technical challenge in building the Cornell robot was providing power in a way that did not interfere with the natural dynamics of the machine, said Collins. "We took special care to make sure the actuators never got in the way by doing negative work," he said. "The motor is on a one-way clutch that ensures that it can only add energy and never absorb it."

It was also challenging to find a foot shape that kept the robot balanced, said Ruina.

The robot walks by moving forward on one leg while the second leg swings forward passively with the knee joint unlocked; the knee joint is locked by a small sprung latch when it reaches full extension. This is also a passive, or nonpowered movement. When this leg hits the ground, it triggers the first leg to push off.

During the push off a spring causes the first leg to extend and push the machine forward. When the ankle has fully extended, a motor pulls the foot up, restoring the energy in the ankle spring. "These springs sort of look like calf muscles, and sort of act like the human Achilles tendon does in human walking," said Collins.

In contrast, most robots directly drive joints with large motors that use gears to control the amount of push a joint receives. "This makes it impossible for the joints to swing freely or for the mechanical system to have dynamics of its own," said Collins. Honda's Asimo, for example, seems to keep its center of mass at the same height across each step, and its feet remain flat on the ground, he said.

This means all the positive work done by the motors is balanced by negative work that the motors must absorb, said Collins. "So Asimo, representative of position-controlled robots, dissipates as much mechanical power as it produces — which is the neighborhood of 390 Watts... to walk," he said.

In mimicking human design the robots are revealing some of the secrets of human walking efficiency.

The Delft robot walks in a way similar to the Cornell robot, but is powered by a pneumatic system that drives its hip joint. It has particularly good balance due to ankles that kinematically couple leaning and steering. This suggests that humans probably link the placement of the leaning foot and stepping foot to aid balance, and hints at better ways to design foot prostheses.

The MIT robot's learning algorithms are also biologically plausible; they mimic the way biological motor learning probably occurs, according to the researchers.

The robot makes small, random changes to the way it takes a step and measures the effect of the change. It combines measurements from previous steps with measurements of the current step to improve its stability.

The combination of the passive walker technology and biologically plausible learning algorithms resulted in a robot that learned much more quickly than previous attempts at producing bipedal robots that teach themselves to walk. The MIT robot learns to walk by rocking back and forth for about 10 minutes, and can start, stop, steer, walk forward, and walk backward.

The combination also showed that very small changes to the control parameters were useful in learning. This allowed the robot to continue to learn and adjust as it walked. The learning system works quickly enough for the robot to adapt to different terrain — like bricks, wooden tiles and carpet — as it walks, according to the researchers' tests.

The passive-dynamic walking robots research is very important, said Stefan Schaal, an associate professor of computer science and neuroscience at the University of Southern California. "It has great potential to accomplish machines that, in the end, will have... high energy efficiency," he said. "If we wish to have autonomous robots to help in our society at some point, it would be [impractical] if the robot needs to recharge every 30 minutes, like is typically the case with the Honda robot." High energy consumption also requires heavy energy supplies, making a robot heavier and thus potentially more dangerous.

The research fits into the bigger picture of human-centered robotics, a well-funded area aimed at producing robots that will be able to assist broad populations, said Schaal. Such models require multi-modal sensing, high levels of dexterity and mobility, safe operation, and energy efficiency, he said.

"Target applications include assistance for the growing elderly population and for people with physical and cognitive disabilities, guidance of children and other at-risk populations on their commute, crowd and emergency response in densely populated areas, robotics rehabilitation and prosthetics, movement instructions for training, exercise and entertainment activities, science education [and] search and rescue efforts in hazardous environments," said Schaal.

Many researchers believe that human-like robots will be the most suitable for these purposes, Schaal added.

The Cornell researchers are working on making a robot that can walk a mile or more, and giving the robot the ability to steer, balance, start and stop. "The MIT 'learning' robot already does this," said Ruina. "But we want to do it while maintaining the efficiency of the Cornell robot."

Foot prostheses inspired by the robots could be ready for practical use in five years, said Collins. Practical bipedal robots are at least 20 years away, he said.

Collins and Ruina's research colleagues were Russ Terake of MIT and Martijn Wisse of Delta University. The work appeared in the February 18, 2005 issue of *Science*. The research was funded by the National Science Foundation (NSF) and the Packard Foundation.

Timeline: 5 years; 20 years
Funding: Government, Private
TRN Categories: Robotics
Story Type: News
Related Elements: Technical paper, "Efficient Bipedal Robots Based on Passive-Dynamic Walkers," *Science*, February 18, 2005

TRN

Software Gives Descriptive Directions

By Eric Smalley, Technology Research News

Automatically-generated directions for getting from one place to another are a staple of the Internet age, but they rarely include landmarks.

Landmarks, however, are an almost indispensable component of directions. They identify places to turn and provide assurance that you are headed the right way.

Researchers from the Massachusetts Institute of Technology are looking to incorporate landmarks into automatically-generated directions using software that models the geographical relationships between spaces and their functions.

The Location Awareness Information Representation software, dubbed Lair, can be used to represent a person's location, what that person is near, and what a person can do at those nearby places. The directions are "similar to those a person would give — [they] use landmarks to identify places to turn," said Gary Look, a researcher at MIT.

The researchers used the software to produce an application that provides walking directions within the Stata Center, the university's new computer science building. The software could eventually be used to produce many types of intelligent trip planning applications, including one that lists the closest places to carry out an errand, said Look.

The system generates directions from a database of information about places, paths and functional descriptions of the places.

Places can be rooms, buildings, neighborhoods, cities, states, regions or countries. Places have six properties: name, on, star, view, contained and function. The "on" property is a list of paths the place is on. The star property is a geometric description of the intersections of the paths that meet at the place. The view property is a list of other places within sight. The contained property is a list of larger places containing the place in question. The function property is a description of how the place is used and what activities can be done there.

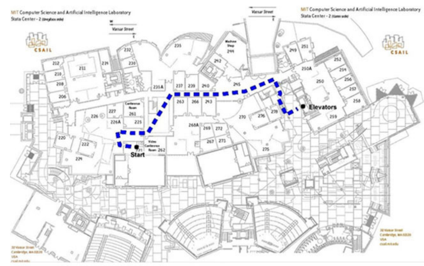
Paths can be roads or hallways. Paths have a name and a row, or a list of places along the path. Place functions have a name and a list of actions that can be performed at the place.

The researchers studied written directions provided by people and determined that indoor walking directions should have certain properties. Walking directions should not use measured distances, compass headings or be limited to "go to" and "turn" instructions. Instead, they should use landmarks to identify turns and verify travel direction, describe the spaces routes pass by or through, use doors as landmarks, and describe hallway intersections.

The system generates a graphical route map, then produces written directions from the map. To derive walking directions from a map, the system groups waypoints into sets that represent segments of a path along the route. The system knows that two paths intersect where two sets share a waypoint, and that in this case a turn is required, according to Look. And because the system models the geometry of intersections — the star property — it can determine which direction to turn.

The system uses two rules for describing turns: use phrases like "turn right at the end of the hallway" to indicate points in routes where paths end, and phrases like "when you enter the lobby, turn left" to incorporate landmarks and functional descriptions of intersections.

And it keeps directions short by using the visibility of landmarks to generate "you will see" phrases. This allows it to avoid having to tell the user to walk straight through every intersection that comes before a turn, according to Look. "Landmarks are also used to assure a person is headed in the right direction," he said.



Source: MIT

The map shows a route through MIT's Stata Center, seen in the photo below, that corresponds to a set of automatically-generated walking directions.

The system indicates when to walk through doors, and includes the functional description of the space on the other side with phrases like "walk through the doorway into the lounge."

It also segments directions into groups based on number of instructions and determines where to split instructions based on geographic similarities. For example, a set of instructions that spans floors could be split to group the instructions by floor.

The researchers have also developed a related tool, the Interactive Simulator for Lair Exploration, that allows users to ask questions about places and routes like "Where am I?", "Describe this place.", "What can I do here?", "How will I know I'm going in the right direction?", "Is place X near place Y?" and "Is place P along my route from X to Y?"

The query tool could be used with handheld computers that track a user's position using indoor equivalents of the Global Positioning System.

The researchers are working to improve the directions-generating system by better understanding how people make decisions based on their surroundings. Their next steps include a formal study of the quality of the system's directions and making it possible to automatically define places and paths from architectural drawings, according to Look.

The method could be used practically in two to five years, said Look.

Look's research colleagues were Buddhika Kottahachchi, Robert Laddaga and Howard Shrobe. The researchers presented the work at the Intelligent User Interfaces conference (IUI'05) held January 9 to 12, 2005 in San Diego, California. The research was funded by the university.

Timeline: 2-5 years
Funding: University
TRN Categories: Databases and Information Retrieval; Human-Computer Interaction
Story Type: News
Related Elements: Technical paper, "A Location Representation for Generating Descriptive Walking Directions," Intelligent User Interfaces conference (IUI'05), San Diego, California, January 9-12, 2005

Springs Simplify Micromirror Arrays

By Kimberly Patch, Technology Research News

Arrays of tiny mirrors that can be precisely positioned are the key components of adaptive optics used in astronomy, biomedical imaging, free-space communications and satellite imaging systems.

Adaptive optics correct light waves that have been distorted, usually by the atmosphere, by bouncing them off a mirror that rapidly changes shape to produce clearer images or signals.

The mirrors in micromirror arrays are typically less than a fifth of a millimeter square and are controlled individually using a mechanism that converts a digital computer signal into a mechanical movement. Large arrays of micromirrors are relatively expensive because they require a large number of electrical digital-to-analog converters to individually address, or control, each micromirror. This also limits the size of an array.

Researchers from the National University of Singapore have found a way make simpler, less expensive mirror controls. At the heart of the researchers' digital-deflection programmable micromirror array is a digital-to-analog converter that works mechanically rather than electrically.

The device controls a large array of micromirrors by addressing them via row and column lines rather than having separate circuits to each mirror. This drastically reduces the number of routing wires needed and allows an array of mirrors to be controlled by off-chip electronics. It also makes it easier to manufacture.

The method promises to reduce the complexity and thus cost and size of devices that use micromirror arrays.

The research could lead to a cost-effective, compact wavefront aberration correction method that uses little power, said Guangya Zhou, a research fellow at the National University of Singapore. "It is also inherently robust and accurate, insensitive to voltage and temperature fluctuations, and suitable for harsh-environment applications where conventional microelectronics might fail," he said.

Each micromirror is moved vertically by a set of microactuators. Each microactuator has two possible positions — an unpowered, or off, position, and a powered, or on, position. A set of springs of different stiffnesses connect the microactuators to the micromirror. The differences in spring stiffness determines how far the mirrors move.

The researchers' built a prototype 2-bit, 3-by-3 micromirror array with 160- by 160-micron mirrors. Each bit in the control signal controls a pair of actuators that move the mirror a specific amount. The on-off combinations of two bits coupled with the two spring stiffnesses yield four mirror positions. The mirror positions in the prototype are set to alter the phase of a 632.8-nanometer wavelength laser beam by one quarter of the wavelength, three-eighths of the wavelength, or leave it as is.

The micromechanical digital-to-analog converter positions the prototype's micromirrors precisely, with a range of 261 nanometers in increments of 87 nanometers. A nanometer is one millionth of a millimeter.

The prototype changes mirror positions in less than 100 microseconds, according to Zhou. A microsecond is one millionth of a second.

The researchers' next step is to build a 4-bit digital-deflection micromirror array that contains 10 by 10 micromirrors. The ultimate goal is to produce a 6-bit device that contains more than 100 by 100 micromirrors, said Zhou.

Such an array could be used as a deformable mobile mirror for eliminating atmospheric blurring in astronomy and space surveillance applications, controlling the quality of communications laser beams that travel through the air, and correcting aberrations in retinal imaging, said Zhou. It could also be used as the optical element in holographic optical tweezers, he said. Optical tweezers use beams of light to trap and manipulate microscopic objects.

It will be 3 to 6 years before the device use ready for commercial use said Zhou.

Zhou's research colleagues were Logeeswaran VJ, Fook Siong Chau, and Francis E. H. Tay. The work appeared in the November 15, 2004 issue of *Optics Letters*. The research was funded by the National University of Singapore.

Timeline: 3-6 years
Funding: University
TRN Categories: MicroElectroMechanical Systems (MEMS); Displays; Optical Computing, Optoelectronics and Photonics; Telecommunications
Story Type: News
Related Elements: Technical paper, "Line-Addressable Digital-Deflection Programmable Micromirror Array," *Optics Letters*, November 15, 2004

Column: Impact Assessment

Roadside Eye Catchers

By Ted Smalley Bowen, Technology Research News

Next time you're cut off by an SUV jock who's slaloming across lanes while dialing a cell phone and swilling java and you start to wonder about natural selection, you might be onto something. Our innate distractibility and nonchalance about risk seem to be pushing us toward our collective limits.

And if in-car activities aren't enough to pull the modern motorist's attention off the road, the landscape is becoming more diverting by the day.

Few regulatory brakes have been applied to this accelerating build-up. While filling in gaps and resolving inconsistencies in traffic safety and behavioral research might bolster the case for restrictions, there seems to be enough evidence to justify a more cautious approach.

The convergence of public, commercialand private interests in this area, and the resulting tensions, reflect the wider debate over the interpretation and use of scientific research. Expressed as a flashing neon sign, it would alternately read "precautionary principle" and "laissez-faire".

Public spaces are verging on Blade Runner-like visual clutter. Electronic displays mounted on taxis and trucks vie with sign-wrapped busses, bus shelters plastered with ads, lighted store signs, and a profusion of billboards, many with revolving panels, flashing lights and video.

Technical advances will only make it easier to liven things up. Nanoscale components promise larger, cheaper, high-resolution video screens that are bound to find their way into signs and surfaces of all kinds.

We're already inundated with ads. Our daily sensory diet includes thousands of commercial images — pop-up ads, animations and video embedded in Web content, TV's full arsenal of moving pictures, billboards and newer forms of advertising planted throughout the outdoor environment.

Thanks to this creative outpouring, outdoor advertising sales are booming - $4.35 billion for the first nine months of 2004, up 6.5 percent from the same period in 2003, according to the Outdoor Advertising Association of America, a trade group.

The advertising arms race has led to increasingly eye-grabbing designs, which for drivers means more potential distractions. But which signs pose a risk? To what extent can commercial signage be blamed for accidents? And what do we know about the nature of attention and distraction?

Research on the effects of roadside advertising on traffic safety goes back to the early 1950s, a few years before Congress green-lighted the vast expansion of the nation's highway system with the Interstate Highway Act of 1956.

While there's no definitive proof of a causal link between signage and accidents, there's much evidence of a correlation. Surveys (1, 2) of the literature show that signs and billboards can compromise traffic safety, especially at intersections and on curves. Flashing lights, motion, visual clutter, and novelty (the Times Square and Vegas Strip formula that's replicating far and wide) are implicated as hazards.

Some of the research on driver distractions bears out the intuitive notion that visual complexity compromises safety by forcing drivers to scan the environment longer for street signs, turns or landmarks.

Researchers are beginning to use eye-tracking devices to monitor drivers in traffic. One such Canadian study suggests that video signs are more distracting than static signs and can act as catalysts, increasing ad gazing of all types, even in unsafe situations.

The surveys also point out a dearth of recent research, especially on signs with rotating-panels and electronic displays. Some attempt has been made to extrapolate from research on cell phones and other distractions, but more applicable studies are needed.

Advances in VR technology should make it easier to study driver behavior in the lab.

In the category of overdue research are studies that consider the effects of visual distractions on young and old drivers, observe the effects of electronic signs in a variety of road configurations and conditions, determine a safe, manageable amount of information that can be displayed on an electronic sign, set standards for maintenance so that signs are legible, and examine the effects of animation, video, and moving panels on drivers.

It's a given that people are easily distracted, but how and why can be hard to pin down. Theories of attention point out relationships between mental excitation (or interest) and the ability to perform tasks — we function best somewhere between boredom and over-stimulation. Still, as researchers studying reflective responses have noted, new or unexpected stimuli trigger involuntary responses. The more bored or unfocused we are, the more susceptible we are to these surprises.

Other researchers have identified modes of visual perception: a focal, or search mode that's narrow and specific, and an ambient mode that's a sort of default, not focused on anything in particular, but with better peripheral awareness.

Studies of distraction (1, 2) have found that computer users performing search tasks in the center of the screen are slowed when objects appear on the perimeter, even when they aren't consciously aware of them. The more peripheral objects, the greater the distraction.

Researchers have also found that new, moving and looming objects command attention; the onset of motion triggers overriding or urgent attention, possibly tapping the survival instinct; and changes in color can capture attention.

None of this proves that ads cause accidents, but behavioral mechanisms obviously come into play when drivers encounter roadside signs. And the intuitive point that content can be a factor in drawing attention is beginning to be tested.

What to make of this? Even allowing that this is a complex issue and the relevant research is a bit sparse, we seem to be relying on the general population as guinea pigs. It looks like the press of new technologies, products and advertising opportunities is getting ahead of public safety and authorities.

The regulatory picture is complex. States regulate outdoor advertising adjacent to interstate and state roads according to guidelines set under the 1965 Highway Beautification Act. State laws are based on the federal guidelines, but vary. Local jurisdictions can enact their own regulations, or adopt state regulations.

In the tug of war over regulation, the laissez-faire argument boils down to demanding proof of a direct, causal link between commercial signs and accidents, whereas courts have generally held that state and local governments can regulate in the interest of traffic safety, said Marya Morris, a senior research associate at the American Planning Association.

Planners are scrambling to keep up with the latest high-tech flashiness, but resources aren't on their side. As animation and video migrate to billboards and other signage, the newer regulations still deal with motion in terms of image changes per minute. Relatively few states have a legal definition of an electronic sign. "The technology has outstripped planners' ability to determine appropriate regulation," Morris said. "It's a head-scratcher, how to allow some businesses to use this kind of machine, but within reason."

And if signs along interstates and some state roadsare found to violate the rules, your cash-strapped local government is likely to have to pony up the removal costs (or leave the signs up), thanks to 1970s revisions of the Highway Beautification Act and similar state provisions.

So, as new eye-catching ads crowd your vistas, delighting and diverting you and your fellow motorists, you can take comfort in the notion that if that SUV finds your bumper, you won't be just another traffic statistic, but a data point.

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