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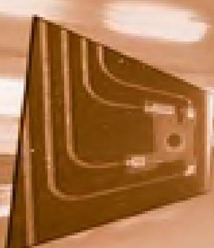
INNOVATION

SPECIAL EDITION

NASA Seeks Partnership with Sensor Industry



The NASA Sensor Initiative
Satellite Sensors Find Fish and Food
Wafer "Wiggle" Going Places

Sensor Webs Are Virtual Explorers

WIRELESS WEBS OF TINY SENSOR PODS created to aid in monitoring biological activity on Earth may eventually be used to help explore other planets.

Scientists at NASA's Jet Propulsion Laboratory (JPL) have created the webs, which will be first used to provide additional information on Earth-based issues like the carbon cycle. Later, the webs could be used to search for evidence of life on Mars or explore the moons of Jupiter.

> "A SENSOR WEB IS CAPABLE OF AUTOMATED REASONING. SENSOR WEBS COULD HAVE AS MUCH AN IMPACT ON THE USE OF SENSORS AS THE INTERNET DID ON THE USE OF COMPUTERS."

A sensor web is a system of wireless, intra-communicating, spatially distributed sensor pods that can be deployed to monitor and explore new environments. According to Kevin Delin, one of the scientists who developed the sensor web concept, each pod collects local information through its sensors and communicates that information wirelessly to neighboring pods. In this way, the information is distributed throughout the entire web. The information is then transmitted to a remote source, such as a computer or mobile phone. Eventually, if the web were used in space exploration, it would transmit the information to a satellite or space probe.

"A sensor web is capable of automated reasoning," Delin said, "because it can perform autonomous operations in uncertain environments, respond to changing environmental conditions and carry out automated diagnosis and recovery. Sensor webs could have as much an impact on the use of sensors as the Internet did on the use of computers.

"Each little pod is like a cell of your body," Delin said. "The sensor webs are different from distributed sensors in that distributed sensor networks gather data and communicate it to a central point. The sensor web pods gather and, more importantly, share information with other pods. The sensor webs modify their behavior on the basis of the collected data."

Sensor Web 3 is currently being developed for the Huntington Botanical Gardens in San Marino, California, also the test site for Sensor Web 2. A botanical greenhouse was chosen for the deployment site of the web for several reasons, according to Delin. "Many basic applications, particularly those in astrobiology and Earth science, would require a suite of sensors similar to those needed in this environment," he said. "Second, a greenhouse would provide somewhat harsh conditions, such as high temperatures, high humidity and dirt, that would make a field test meaningful."

The information collected by Sensor Web 3 includes measurements of air temperature, soil temperature, relative humidity, soil moisture and the light level. "Sensor webs offer us the means to make sensitive measurements over large areas," Delin added. "A major thrust of our current effort is to develop a sensor web that can detect, identify and monitor biological activity. For example, trace biosignature gases are very important if you are a biogeochemist trying to understand the carbon cycle on Earth or searching for microorganisms living beneath the surface of a planet."

The sensors themselves can determine the cost of deploying a sensor web, since the sensors and hardware being used in the sensor pods are commercially available, off-the-shelf products that have been developed for computers and mobile telephones.

The JPL Sensor Webs Project is also beginning to develop a partnership with NASA Kennedy Space Center to look at marine biology in the area.

According to Delin, the sensor web also has applications for saving human life in space and on Earth. The sensor web can show the direction of gas flow and available exit routes by providing vectored direction in both time and space. "The webs can be used in space to not only detect a loss of pressure in a spacecraft, but to pinpoint the leak so the correct section of the craft can be closed off.

"And imagine if you had sensor webs in your house," Delin said, "so that instead of just having a smoke alarm go off, you actually had an idea which direction the fire is coming from so you knew how to escape it."

For more information, visit *http://sensorwebs.jpl.nasa.gov*, or contact Kevin Delin at Jet Propulsion Laboratory, 818/354-9647, *kevin.delin@jpl.nasa.gov* Please mention you read about it in *Innovation*.

Satellite Sensors Find Fish and Food

SCIENTISTS USING SATELLITE DATA DISCOVered an unusual, long-lasting, whirlpool-like ocean eddy that generated a dramatic increase in the marine food supply off the Hawaiian coast in 1999.

The eddy, named Loretta, began spinning up in the Alenuihaha Channel between the islands of Hawaii and Maui during mid-May 1999 and maintained a presence in the lee of the Hawaiian Islands until January 2000. Over the eight-month period, the eddy's churning motion brought up a great amount of nutrients from the ocean depths, enhancing the plankton population on the ocean's surface, and providing a banquet for marine life.

Several organizations collaborated to track Loretta and other Hawaiian eddies and their ecological benefits. The University of Hawaii, NASA and the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) integrated information from two independent satellite sensors that measure sea surface temperature (SST) and ocean color. The Sea-viewing Wide Field-of-View Sensor (SeaWiFS) satellite tracked ocean chlorophyll, and NOAA's Geostationary Operational Environmental Satellite-10 (GOES) satellite tracked sea surface temperatures. Data from shipboard measurements taken aboard the NOAA ship Townsend Cromwell were also used to see the efforts of Loretta in subsurface waters, since satellite observations are restricted to the ocean surface.

"Eddies naturally occur in this locale for periods of several weeks to a few months, but Loretta

SENSOR TECHNOLOGY INDUCTED INTO HALL OF FAME

An advanced sensor developed at NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California, was inducted into the U.S. Space Foundation Hall of Fame on April 12, 2001, in recognition of its potential uses in medicine, firefighting and industry, as well as astronomy.

The Quantum Well Infrared Photodetector (QWIP) technology has been licensed for various commercial applications, including non-invasive detection of breast and skin cancers.

Physicians use it during brain surgery to visualize a tumor's perimeter. The QWIP camera's ability to see through dust and smoke has proven useful to firefighters and helicopter camera crews by allowing them to see forest fire hot spots from the air through heavy smoke. The technology also has many other potential uses from search and rescue, to spotting faulty welds and blockages, to volcano observation.

"It is a great pleasure to see something we developed being used for public benefit," said Sarath Gunapala, co-inventor and principal engineer of the sensor developed at JPL, "especially in medical applications, such as the early detection of cancer."

The ability of the camera to see in the infrared has been useful for NASA. Astronomers at Palomar Observatory have also taken advantage of the ability to see in the infrared through dust clouds and image deep into dusty star-forming regions where visible sensors cannot penetrate.

The U.S. Space Foundation's Space Technology Hall of Fame honors individuals, organizations and companies who have taken technologies originally designed for the space program and later adapted them for commercial application on Earth. The QWIP technology was inducted during the Foundation's National Space Symposium, April 9–12, 2001, in Colorado Springs, Colorado. Three other JPL technologies have made the Hall of Fame: the Active Pixel Sensor in 1999 and, in 1994, Digital Image Processing and an Excimer Laser Angioplasty System.

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