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Computer scientists and animal care experts at the University of California, San Diego (UCSD) have come up with a new way to automate the monitoring of mice and other animals in laboratory research. Combining cameras and distributed, non-invasive sensors with elements of computer vision, information technology and artificial intelligence, the Smart Vivarium project aims to enhance the quality of animal research, while at the same time enabling better health care for animals.

The pilot project is led by Serge Belongie, an assistant professor in Computer Science and Engineering at UCSD's Jacobs School of Engineering. It is funded entirely by the California Institute for Telecommunications and Information Technology [Cal-(IT)²], a joint venture of UCSD and UC Irvine. "Today a lot of medical research relies on drug administration and careful monitoring of large numbers of live mice and other animals, usually in cages located in a vivarium," said Belongie. "But it is an entirely manual process, so there are limitations on how often observations can be made, and how thoroughly those observations can be analyzed."

Belongie put together an interdisciplinary team to develop the hardware and software for automated, 24-hour-a-day monitoring and archiving of a continuous stream of measurements on animal behavior - rather than periodic observations by a lab technician. So far, Belongie has demonstrated the computer-vision and pattern-recognition software with data from a single cage, but the deployment inside a full-scale vivarium is still in the proposal stages. Noted Belongie: "We are now hoping to embark on a multi-million-dollar project that would allow us to develop and deploy the technology for two key areas - medical research, and emergency response."

UCSD is a major biological sciences research center, and animal-care specialists believe the technology under development could dramatically improve the care of research animals. "The Smart Vivarium will make better use of fewer lab animals and lead to more efficient animal health care," said Phil Richter, Director of UCSD's Animal Care Program, who is working with Belongie on the project. "Sick animals would be detected and diagnosed sooner, allowing for earlier treatments." The technology would also help to reduce the number of animals needed in scientific investigations. "In medical research, experiments are sometimes repeated due to observational and analytical limitations," said Belongie. "By recording all the data the first time, scientists could go back and look for different patterns in the data without using more mice to perform the new experiment."

For many of the same reasons, the underlying technology could be useful for the early diagnosis and monitoring of sick animals in zoos, veterinary offices and agriculture. ("Early detection of lameness in livestock," noted Belongie, "could help stop the transmission of disease.") The computer scientist also intends to seek

collaboration with the San Diego Zoo and other local institutions for practical field deployment of the monitoring systems as part of an upcoming study.

A possible ancillary use for this technology could be for emergency response, specifically, for monitoring so-called 'sentinel' cages. "This is the modern-day version of the canary in a coal mine," said Belongie. "Animals can be very sensitive to chemical or biological agents, and sentinel cages have already been deployed at potential bio-terrorism targets and chemical research facilities to warn operators of gas or other leaks. Instead of requiring that a human watch each animal in each cage for early warning signs, the Smart Vivarium technology would automate the process, resulting in reduced need for such sentinels."

As for improvements in medical research from the continuous monitoring of lab animals, Belongie expects at least an improvement of two orders of magnitude in the automated collection and processing of monitoring data. "Continuous monitoring and mining of animal physiological and behavioral data will allow medical researchers to detect subtle patterns expressible only over lengthy longitudinal studies," noted Belongie. "By providing a never-before-available, vivarium-wide collection of continuous animal behavior measurements, this technology could yield major breakthroughs in drug design and medical research, not to mention veterinary science, experimental psychology and animal care."

Apart from Belongie and officials from the UCSD Animal Care Program, two Jacobs School of Engineering faculty members are collaborating on the project: Bioengineering professor Geert W. Schmid-Schonbein, a leader in microcirculation research, who is providing input on how to maximize the utility of the design of the Smart Vivarium; and Computer Science and Engineering professor Rajesh Gupta, who is leading the effort to create a distributed, embedded platform that will integrate all of the functions in a tiny silicon-based package that could be mounted on existing lab cages without requiring a wholesale redesign of cages used by vivarium operators. "This project typifies the interdisciplinary nature of our research," said Ramesh Rao, UCSD Division Director of Cal-(IT)². "Professor Belongie and his colleagues are working to produce a practical system that will require overcoming huge research challenges in areas as diverse as computer vision, bioengineering, embedded systems design, and animal care protocols. And based on the pilot project so far, they are off to a good start."

Note to Editors: Photos of Professor Belongie and a computer vision-enabled cage can be downloaded from the Faculty & Students and Research sections of the Image Gallery at http://www.jacobsschool.ucsd.edu/news_events/gallery/.

About Cal-(IT)²

The California Institute for Telecommunications and Information Technology is one of four institutes created by the State in late 2000 to ensure that California maintain its leadership in cutting-edge technologies. Cal-(IT)²'s mission: to extend the reach of the current information infrastructure throughout the physical world - enabling anywhere/anytime access to the Internet. More than 220 professors and senior researchers from UC Irvine and UC San Diego are collaborating on interdisciplinary projects. www.calit2.net.

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