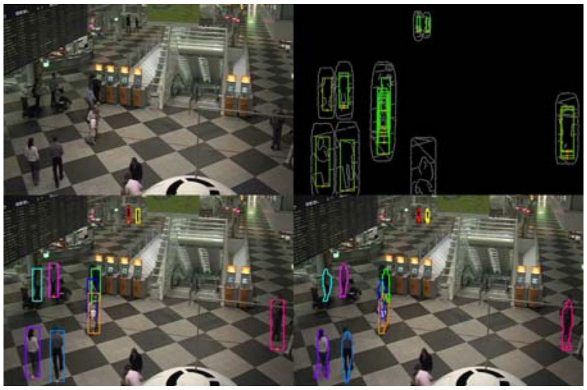
Computer Vision: Visual-Event Recognition for Security and Science



The proliferation of digital imaging technology has revolutionized both security surveillance and scientific inquiry, creating enormous opportunities and significant challenges. Digital surveillance cameras record billions of hours of security footage each year, providing both theft deterrence and forensic evidence. However, the shear volume of surveillance video makes it difficult for people to monitor, process, and respond to recorded events. Scientists use high-resolution digital imaging to document minute physical and biological processes, but some observed phenomena are impossible for human eyes to see, even with digital enhancement.

The Computer Vision Laboratory (CVL) at the University of Maryland is addressing these problems with technologies that help computers "see" important patterns in digital images.

Rama Chellappa develops ways to track people through large settings with high camera density, such as airports and train stations. He is also designing digital face-recognition programs for security checkpoints.

Larry Davis creates computer applications that interpret gestures and movement to automatically identify dangerous situations.

Yiannis Aloimonos and David Jacobs are tuning computer vision algorithms to make medical diagnoses more accurate. Jacobs is also developing programs to help botanists identify plants.

Computer Vision Laboratory www.cfar.umd.edu/cvl

Security and Safety Applications

Video surveillance cameras are everywhere—in parking lots and banks, in parks and stadiums, in malls and train stations and airports. With so many cameras, the challenge is not acquiring surveillance data but gleaning what is valuable. What can be ignored? What demands attention? How do we cope with so much streaming video when there just aren't enough eyeballs to assess all that is recorded? Researchers at CVL are developing digital tools to solve such security problems.

Improved Security Surveillance through Digital Pattern Recognition

Suppose a man is acting strangely at Grand Central Station in New York. Is he intoxicated, planting a bomb, or having a seizure? Could a computer recognize the strange behavior and alert the appropriate authorities? Rama Chellappa and Larry Davis are developing streaming video systems that use gait recognition and object recognition to detect abnormal activities and alert authorities to those events that demand specific responses.

Chellappa's and Davis's applications have great potential for airports, where people and vehicles tend to move in predictable ways. Working with Honeywell and with funding from the Department of Defense, CVL researchers have taken sample videos in the Minneapolis-St. Paul airport to create a data set for testing their systems. The objective is to build real-time systems whose "smart cameras" can make coordinated inferences based on normal and abnormal image patterns. A relatively simple computer program could send out a warning if a fuel tanker failed to show up to service a plane that needed fueling. More sophisticated gait-recognition programs can "see" that a person is carrying a concealed weapon by the way he walks.

Chellappa and Davis are currently developing an algorithm that responds to “human gait DNA”—specific patterns in walking styles. By measuring strides, body angles, and the swinging of arms and legs, and by superimposing these image variables on top of one another, the system can determine both normal and anomalous activities—such as carrying a concealed gun. Moreover, the system does not have to “see” everything to make an informed inference about partially recorded events. For example, the gait-recognition algorithm could deduce that a person dropped a package—even if the drop event was not recorded—by comparing gait patterns before and after the drop.

Video Cameras for Face Recognition

Rama Chellappa and CVL researchers have developed a digital face-recognition system for seamless access control at security checkpoints. The system uses digital cameras to scan the faces of people approaching a security gate. Algorithms process patterns of light distribution, and the patterns are then compared to the facial “fingerprints” in the system’s database. Approved faces are cleared for access, and all others are rejected.

Chellappa’s working model can successfully match videos of faces for sets of up to 30 people. The Defense Advanced Research Agency (DARPA) is funding a project to test face recognition among larger numbers of people and to enable face recognition at a distance.

Video Cameras to Improve Safety

Beyond security, computer-vision systems may have their greatest impact in industrial inspection applications, such as systems for monitoring worker safety in factories. For example, “smart” cameras can track where a worker is looking and react if the worker is not paying attention to a potentially dangerous part of a task.

In a project funded by the Department of Transportation, CVL researchers have developed ways to tell when a truck driver is dozing off and no longer watching the road. This system could reduce fatigue-related accidents by waking drowsy truckers and directing them to the nearest rest area.

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Medical and Scientific Applications

Computer Vision to Help People Heal

Video-pattern recognition holds tremendous potential in medicine, particularly in physical therapy and neuroscience. Yiannis Aloimonos and David Jacobs are using high-resolution video to record subtle variations in patients with movement disorders, such as someone recovering from a serious accident. This system could provide clues for physical therapists that they might otherwise miss, leading to better diagnoses and faster healing. Aloimonos’s and Jacobs’s computer-vision system can also help interpret the gestures of patients with brain trauma, which can aid neurologists in assessing the damage or progress of a disease or impairment.

Helping Botanists Identify Plants

Though Jacobs’s research spans a range of topics in computer vision, his primary focus has been on object recognition—the identification of specific objects within digital images. More specifically, he works to overcome significant issues in computerized object recognition, such as “seeing” the same object under variable lighting conditions and identifying objects that deform or vary in rigidity. In collaboration with researchers at Columbia University and the Smithsonian Institution, Jacobs is helping to develop programs that can automatically identify plants from photographs of leaves taken under any conditions. Ultimately, field botanists on collection trips could be equipped with mobile devices that could instantly compare a field image against a database of 95,000 plant species.

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