Digital Noise Sharpens Vague Images

A good, clear picture may be worth a thousand words. But how much is a fuzzy image worth?

That depends on how much information a viewer can obtain from the image and on whether the information proves useful. Enrico Simonotto, a physicist at the University of Genoa in Italy, and his colleagues have found that adding randomized signals or background noise resembling the snow seen in weak television pictures sometimes enhances a faded image.

Adding noise, it seems, can lift a barely detectable image above the brain's perceptual threshold so that people viewing the image can grasp some details that would otherwise be lost.

"Our goal is to see how noise affects the way the brain processes information," Simonotto said at last week's meeting of the American Physical Society in St. Louis.

Starting with a clear digitized image of a face, the researchers used computer graphics to lower the contrast until the features were no longer distinguishable.

Simonotto *et al.*

Digital noise can enhance perception of a low-contrast image. The contrast in the photo above (left) was reduced until the face was no longer perceptible. Increasing the amount of fluctuating noise improves the image slightly and optimally (center images). Too much noise (right) distorts the image.

The group then added randomized digital signals, which can be described mathematically as a type of stochastic resonance (SN: 7/22/95, p. 55).

"We found that by adding noise alone, some of the original picture's details could be perceived," Simonotto says. Moreover, by testing noise at different frequencies, the team further improved the quality of the picture.

The brain somehow uses the noise to reconstruct pieces of the picture lost from the original. "If you look at a weak image of my face, for example, you get a hint of a human face but not much more," Simonotto says. "Am I wearing glasses? Without adding noise to the image, you can't tell."

The amount and type of noise added to the image affects the way viewers discern a picture's details. For example, a fast, fluctuating noise enhanced images more effectively than static noise did.

Theories of stochastic resonance arose in 1981 as physicists sought to explain the periodicity of Earth's ice ages. Subsequently, scientists brought the mathematical theory to bear on biological problems, using it to describe how animals such as crayfish sense their environment. Meanwhile, neuroscientists were also learning that the brain, despite its exquisite precision as an information processor, generates much internal noise, says Frank Moss, a biophysicist at the University of Missouri-St. Louis.

"Neurons are noisy," Moss says. "If you measure signals in the brain or in a sensory organ, you mostly detect random firings. One of the brain's strengths as a computer is its ability to extract information from noisy signals."

"Think of the brain as an instrument filled with sloppy amplifiers," says Martin B. Stemmler, a computational neuroscientist at the California Institute of Technology in Pasadena. "Our visual system averages lots of signals, distinguishing real ones in the external world from internally generated noise of the brain's own circuitry. This is all part of successful image processing.

"Simonotto's work brings together knowledge from video engineering, computational neuroscience, and the theory of stochastic resonance," Stemmler says. "An interesting question to pursue is how the brain uses noise to enhance images."

Though this work remains preliminary, Simonotto says it may someday prove useful in systems that help humans see in visually challenging circumstances—at night, in snow or fog, or underwater.

— R. Lipkin

One diagnosis, too many mastectomies

Women beware. A particular kind of breast cancer diagnosis may be generating an epidemic of needless mastectomies.

The diagnosis is ductal carcinoma in situ. Once used to describe a life-threatening malignancy of the milk ducts, the term has come in the last 30 years to be applied to a spectrum of tumors that turn malignant only late in their course, if at all.

Yet many surgeons—whose aggressive approach to this cancer stems from the days when tumors weren't diagnosed until they were well advanced—still remove the breast.

Mammography, by pinpointing thousands of small carcinomas that would not have been detected in years past, appears to have led to a spate of mastectomies, California researchers report in the March 27 JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION.

The disease itself was always there—what's new is the ability to detect it early, says Roy A. Jensen of Vanderbilt University Medical Center in Nashville. Jensen reported in the Oct. 1, 1995 CANCER that just one-fourth of ductal carcinomas blossom into invasive disease.

The California team examined National Cancer Institute reports on 16,706 cases of breast cancer between 1973 and 1992. They found that the number of ductal carcinoma cases soared from 4,900 in 1983 to 23,368 in 1992, or about 12 percent of all new breast cancers. In 1992, 10,242 of the women with ductal carcinoma had mastectomies.

"The proportion of cases treated by mastectomy may be inappropriately high, particularly in some areas of the United States," the researchers conclude. Doctors in New Mexico treat nearly 60 percent of ductal carcinomas with mastectomy. In Connecticut, surgeons remove a breast one-third of the time.

Mastectomy should be a last resort, says team member Virginia L. Ernster of the School of Medicine at the University of California, San Francisco. "We only care about cancer if it invades and becomes clinically significant or life-threatening."

The trouble is, no one knows which ductal carcinomas will become invasive. "We're now at the point where we have enough information to design clinical trials to decide how to treat this thing," asserts Jensen, coauthor of an editorial accompanying the California study.

Erstner agrees that new treatment guidelines would help. Many early breast malignancies are treated by removing the lump and surrounding tissue and, sometimes, irradiating the site. Many cases of ductal carcinoma could be treated similarly, she says.

— S. Sternberg