NIST Math Technique Opens Clearer Window on Universe

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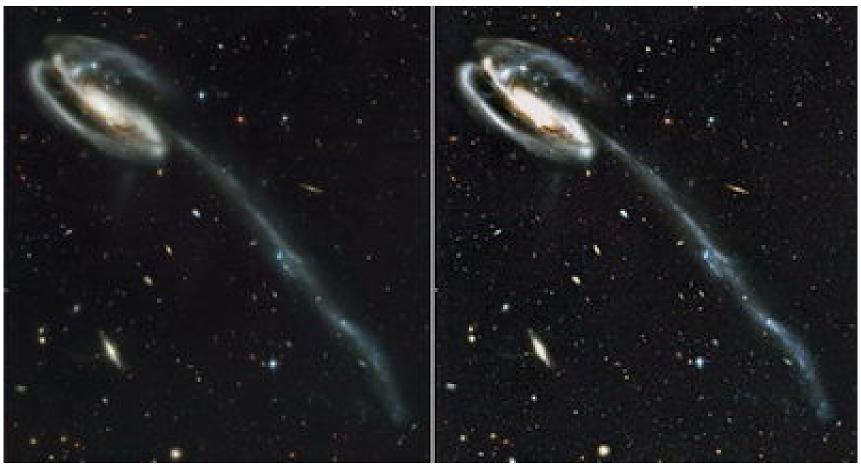

A: Galaxy UGC 10214 (“Tadpole”), imaged in 2002 by the Advanced Camera for Surveys (ACS) aboard NASA&acutes Hubble Space Telescope, shows what NASA called a “Whitman&acutes Sampler of galaxies” from the universe’s 13-billion-year evolution. B: Applying the APEX method to the Tadpole galaxy image brings both “foreground” objects and background galaxies into significantly sharper focus. Credit: NASA/NIST

A fast, efficient image enhancement technique developed at the National Institute of Standards and Technology and originally applied to improving monochrome microscope images has proved itself equally effective at the other end of the scale— sharpening details on color images of distant galaxies produced by the Hubble Space Telescope. That the technique’s practical value would span from inner space to outer space was a welcome surprise to NIST mathematician Alfred Carasso.

Removing blur is a problem common to almost all imaging, from home snapshots to scientific instrumentation. Mathematically, blurring can be thought of as a set of mathematical operations that are applied to every point in an image and that result in that point being spread out and diffused. In principle, if you know the blurring function, the exact set of operations, you can remove the blur by delicate numerical analysis, being careful not to amplify noise.

But usually you don't know that. Many things go into blur—motion of the object, motion of the imager, irregularities in the optics, atmospheric effects ... the list goes on. As a rule, the precise mathematical transformation, the "point spread function," is unknown. In 2001, Carasso developed a technique – the APEX* method—as a general solution to a specific limited class of blur: blur that is symmetric and has certain other mathematical characteristics. APEX is based on a major simplifying assumption that leads to a big pay-off: it's fast and it's "blind" - it doesn't need to know the underlying point spread function in advance, but it can deduce it from the image.

Not every image is suitable for APEX enhancement because of its basic assumptions, but a remarkably large number are. At NIST, APEX originally was applied to deblurring images from scanning electron microscopes, and it also has been applied to some medical imaging.

In a recent paper**, Carasso applied APEX to astronomical images, including color images from the Hubble Advanced Camera for Surveys (ACS), NASA's most advanced imaging system. Deblurring color images is even more involved, because the (still unknown) point spread function can be different for different color components. And there was no reason to expect APEX to work anyway, Carasso observes. Regardless, APEX successfully detected and corrected unusual optical blurring functions in several astronomical images and delivered strikingly enhanced versions of well-known Hubble images, including the

Whirlpool and Tadpole galaxies. “There is an element of luck in scientific research,” Carasso says, “sometimes a simple formulation, based on the right intuition, works out a lot better than you ever expected.”

*APEX is *not* an acronym.
**A.S. Carasso. APEX blind deconvolution of color Hubble space telescope imagery and other astronomical data. *Optical Engineering*. 45, Number 10, October 2006, 107004

Source: NIST