For new microscope images, less is more

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When people email photos, they sometimes compress the images, removing redundant information and thus reducing the file size. Compression is generally thought of as something to do to data after it has been collected, but mathematicians have recently figured out a way to use similar principles to drastically reduce the amount of data that needs to be gathered in the first place. Now scientists from the University of Houston and Rice University in Houston, Texas have utilized this new theory, called compression sensing, to build a microscope that can make images of molecular vibrations with higher resolution and in less time than conventional methods. The microscope provides chemists with a powerful new experimental tool.

The main concept behind compressive sensing is something called "sparsity." If a signal is "sparse," the most important information is concentrated in select parts of the signal, with the rest containing redundant information that can be mathematically represented by zero or near-zeros numbers. The sparse signal that the Texas researchers were looking at came from a sum frequency generation (SFG) microscope, which shines two different frequency lasers at a surface and then measures the return signal to gather information about the vibration and orientation of the molecules at the surface boundary.

Traditional SFG microscopes scan a sample by systematically moving across it, but the resolution of these traditional scans is limited because as resolution increases the strength of the signal decreases. Instead of systematically scanning the boundary, the compressive sensing microscope gathered a set of pseudo-randomly positioned sampling points. If the important information was captured in the sample, then a series of mathematical steps could be used to construct the entire image. The researchers tested their microscope by imaging stripes of gold deposited on a silicon background and then coated with a chemical called octadecanethiol. The device sensed the stretching of the carbon-hydrogen bonds in the octadecanethiol layer and created images with 16 times more pixel density than was possible with the traditional scanning techniques. The new microscope could find applications in biomolecular imaging and the scientific study of interfaces.

More information: "Sum Frequency Generation-Compressive Sensing Microscope" is accepted for publication in the *Journal of Chemical Physics.*

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