Algorithm for Wavefront Sensing Using an Extended Scene

The restriction to a point source has been removed.

NASA's Jet Propulsion Laboratory, Pasadena, California

A recently conceived algorithm for processing image data acquired by a Shack-Hartmann (SH) wavefront sensor is not subject to the restriction, previously applicable in SH wavefront sensing, that the image be formed from a distant star or other equivalent of a point light source. That is to say, the image could be of an extended scene. (One still has the option of using a point source.) The algorithm can be implemented in commercially available software on ordinary computers.

The steps of the algorithm are the following:

1. Suppose that the image comprises M sub-images. Determine the x,y Cartesian coordinates of the centers of these sub-images and store them in a $2 \times M$ matrix.
2. Within each sub-image, choose an $N \times N$-pixel cell centered at the coordinates determined in step 1. For the ith sub-image, let this cell be denoted as $s_i(x,y)$. Let the cell of another sub-image (preferably near the center of the whole extended-scene image) be designated a reference cell, denoted $r(x,y)$.
3. Calculate the fast Fourier transforms of the sub-sub-images in the central $N' \times N'$ portions (where $N' < N$ and both are preferably powers of 2) of $r(x,y)$ and $s_i(x,y)$.
4. Multiply the two transforms to obtain a cross-correlation function $C_i(u,\nu)$, in the Fourier domain. Then let the phase of $C_i(u,\nu)$ constitute a phase function, $\varphi(u,\nu)$.
5. Fit u and ν slopes to $\varphi(u,\nu)$ over a small u,ν subdomain.
6. Compute the fast Fourier transform, $S_i(u,\nu)$ of the full $N \times N$ cell $s_i(x,y)$. Multiply this transform by the u and ν phase slopes obtained in step 4. Then compute the inverse fast Fourier transform of the product.
7. Repeat steps 4 through 6 in an iteration loop, cumulating the u and ν slopes, until a maximum iteration number is reached or the change in image shift becomes smaller than a predetermined tolerance.
8. Repeat steps 4 through 7 for the cells of all other sub-images.

This work was done by Erkin Sidick, Joseph Green, Catherine Ohara, and David Redding of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

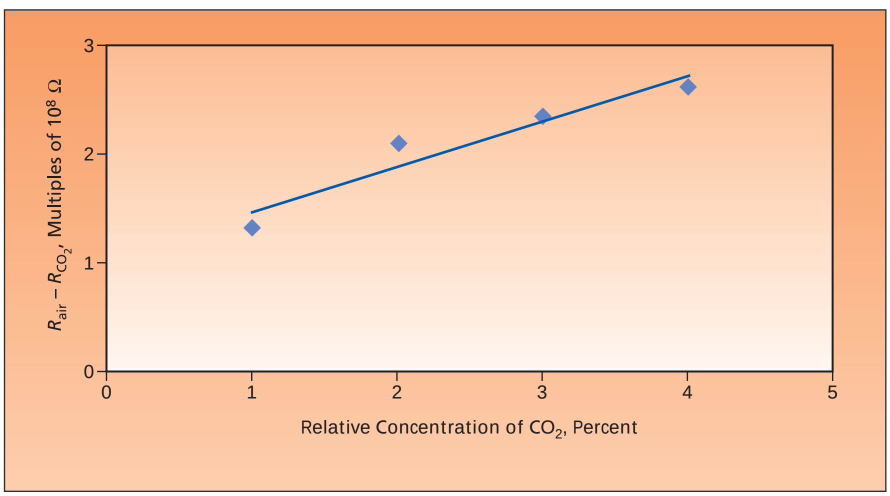
The software used in this innovation is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-44770.

CO_2 Sensors Based on Nanocrystalline SnO_2 Doped With CuO

Miniature CO_2 sensors could be mass-produced inexpensively.

John H. Glenn Research Center, Cleveland, Ohio

Nanocrystalline tin oxide (SnO_2) doped with copper oxide (CuO) has been found to be useful as an electrical-resistance sensory material for measuring the concentration of carbon dioxide in air. SnO_2 is an n-type semiconductor that has been widely used as a sensing material for detecting such reducing gases as carbon monoxide, some of the nitrogen oxides, and hydrocarbons. Without doping, SnO_2 usually does not respond to carbon dioxide and other stable gases. The discovery that the electrical resistance of CuO-doped SnO_2 varies significantly with the concentration of CO_2 creates opportunities for the development of relatively inexpensive CO_2 sensors for detecting fires and monitoring atmospheric conditions. This discovery could also lead to research that could alter fundamental knowledge of SnO_2 as a sensing material, perhaps leading to the development of SnO_2-based sensing materials for measuring concentrations of oxidizing gases.



The **Electrical Resistance** of a 1:8 CuO:SnO_2 film fabricated as described in the text was found to decrease as the concentration of CO_2 in air increased. R_{air} signifies the resistance of the film in pure air; R_{CO_2} signifies the resistance of the film at the indicated concentration of CO_2.

Prototype CO_2 sensors based on CuO-doped SnO_2 have been fabricated by means of semiconductor-microfabrication and sol-gel nanomaterial-synthesis batch processes that are amendable to inexpensive implementation in mass production. A fabrication process like that of the prototypes includes the following major steps:

1. Platinum interdigitated electrodes are