from laser diodes that are located away from the crystal to aid in dissipating the heat generated in the diodes and their drive circuits. The output of the Nd:YVO₄ crystal has a wavelength of 1064 nm, and is made to pass through frequency-doubling and frequency-tripling crystals. As a result, the net laser output is a collinear superposition of beams at wavelengths of 1064, 532, and 355 nm.

The laser operates at a pulse-repetition rate of 5 kHz, emitting per-pulse energies of 50 µJ at 1064 nm, 25 µJ at 532 nm, and 50 µJ at 355 nm. The transmitted laser beam and the returning laser light backscattered from atmospheric aerosols and molecules pass through a telescope, the primary optical element of which is an off-axis parabolic mirror having an aperture diameter of 20 cm. The combination of the off-axis arrangement and other features is such that none of the transmitting aperture is obscured and only about 20 percent of the receiving aperture is obscured.

The returning light collected by the telescope is separated into wavelength components by use of dichroics and narrowband interference filters suppress solar background. The 1064-nm signal is further separated into parallel and perpendicular polarization components. A half-wave plate is inserted in the 1064-nm path to enable calibration of the parallel- and perpendicular-polarization channels. Each resulting output wavelength component is coupled via an optical fiber to a photodetector.

A Three-Input Inverse Majority Gate

As proposed would be a microscopic vacuum electronic device containing bundles of carbon nanotubes positioned between gate electrodes to obtain controlled field emission of electrons from the bundles. In the presence of a fixed positive bias potential on the anode, the application of suitable (possibly smaller) bias potential to any two or all three gate electrodes would divert all the electron current from the anode.
Reduced-Order Kalman Filtering for Processing Relative Measurements

A Kalman filter can be propagated using fewer computations.

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A study in Kalman-filter theory has led to a method of processing relative measurements to estimate the current state of a physical system, using less computation than has previously been thought necessary. As used here, “relative measurements” signifies measurements that yield information on the relationship between a later and an earlier state of the system. An important example of relative measurements arises in computer vision: Information on relative motion is extracted by comparing images taken at two different times.

Relative measurements do not directly fit into standard Kalman filter theory, in which measurements are restricted to those indicative of only the current state of the system. One approach heretofore followed in utilizing relative measurements in Kalman filtering, denoted state augmentation, involves augmenting the state of the system at the earlier of two time instants and then propagating the state to the later time instant. While state augmentation is conceptually simple, it can also be computationally prohibitive because it doubles the number of states in the Kalman filter.

In many practical applications, relative measurements are not functions of entire earlier states but rather may be a function of only a subset of elements of the earlier state. A relative measurement that can be thus characterized is denoted a partial relative measurement. For example, in computer vision, relative-measurement information is usually a function of position rather than velocity, acceleration, or other elements of the state.

When processing a relative measurement, if one were to follow the state-augmentation approach as practiced heretofore, one would find it necessary to propagate the full augmented state Kalman filter from the earlier time to the later time and then select out the reduced-order components. The main result of the study reported here is proof of a property called reduced-order equivalence (ROE). The main consequence of ROE is that it is not necessary to augment with the full state, but, rather, only the portion of the state that is explicitly used in the partial relative measurement. In other words, it suffices to select the reduced-order components first and then propagate the partial augmented state Kalman filter from the earlier time to the later time; the amount of computation needed to do this can be substantially less than that needed for propagating the full augmented Kalman state filter.

This work was done by Harish Manohara and Mohammad Mojarradi of Caltech for NASA’s Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

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