Range Imaging Without Moving Parts

Potential applications include proximity detection, robotic vision, and terrain mapping.

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Range-imaging instruments of a type now under development are intended to generate the equivalent of three-dimensional images from measurements of the round-trip times of flight of laser pulses along known directions. These instruments could also provide information on characteristics of targets, including roughnesses and reflectivities of surfaces and optical densities of such semi-solid objects as trees and clouds. Unlike in prior range-imaging instruments based on times of flight along known directions, there would be no moving parts; aiming of the laser beams along the known directions would not be accomplished by mechanical scanning of mirrors, prisms, or other optical components. Instead, aiming would be accomplished by using solid-state devices to switch input and output beams along different fiber-optic paths. Because of the lack of moving parts, these instruments could be extraordinarily reliable, rugged, and long-lasting.

An instrument of this type would include an optical transmitter that would send out a laser pulse along a chosen direction to a target. An optical receiver co-aligned with the transmitter would measure the temporally varying intensity of laser light reflected from the target to determine the distance and surface characteristics of the target.

The transmitter would be a combination of devices for generating precise directional laser illumination. It would include a pulsed laser, the output of which would be coupled into a fiber-optic cable with a fan-out and solid-state optical switches that would enable switching of the laser beam onto one or more optical fibers terminated at known locations in an array on a face at the focal plane of a telescope. The array would be imaged by the telescope onto the target space.

The receiver optical system could share the aforementioned telescope with the transmitter or could include a separate telescope aimed in the same direction as that of the transmitting telescope. In either case, light reflected from the target would be focused by the receiver optical system onto an array of optical fibers matching the array in the transmitter. These optical fibers would couple the received light to one or more photodetector(s). Optionally, the receiver could include solid-state optical switches for choosing which optical fiber(s) would couple light to the photodetector(s).

This instrument architecture is flexible and can be optimized for a wide variety of applications and levels of performance. For example, it is scalable to any number of pixels and pixel resolutions and is compatible with a variety of ranging and photodetection methodologies, including, for example, ranging by use of modulated (including pulsed and encoded) light signals. The use of fixed arrays of optical fibers to generate controlled illumination patterns would eliminate the mechanical complexity and much of the bulk of optomechanical scanning assemblies. Furthermore, digital control of the selection of the fiber-optic pathways for the transmitted beams could afford capabilities not seen in previous three-dimensional range-imaging systems. Instruments of this type could be specialized for use as, for example, proximity detectors, three-dimensional robotic vision systems, airborne terrain-mapping systems, and inspection systems.

This work was done by J. Bryan Blair, V. Stanley Scott III, and Luis Ramos-Izquierdo of Goddard Space Flight Center. Further information is contained in a TSP (see page 1).
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