Progress in Insect-Inspired Optical Navigation Sensors

Some details of implementation have become available.

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Progress has been made in continuing efforts to develop optical flight-control and navigation sensors for miniature robotic aircraft. The designs of these sensors are inspired by the designs and functions of the vision systems and brains of insects. Two types of sensors of particular interest are polarization compasses and ocellar horizon sensors.

The basic principle of polarization compasses was described (but without using the term “polarization compass”) in “Insect-Inspired Flight Control for Small Flying Robots” (NPO-30545), NASA Tech Briefs, Vol. 29, No. 1 (January 2005), page 61. To recapitulate: Bees use sky polarization patterns in ultraviolet (UV) light, caused by Rayleigh scattering of sunlight by atmospheric gas molecules, as direction references relative to the apparent position of the Sun. A robotic direction-finding technique based on this concept would be more robust in comparison with a technique based on the direction to the Sun because the UV polarization pattern is distributed across the entire sky and, hence, is redundant and can be extrapolated from a small region of clear sky in an elsewhere cloudy sky that hides the Sun.

Three different implementations of a polarization compass are under consideration. Each implementation offers distinct advantages and disadvantages relative to the others:

• In the lightest and least power-consumptive implementation, the polarization signal in the sky is strongest in blue light.

This work was done by Eric Bloemhof and J. Kent Wallace of Caltech for NASA’s Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

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production version, power consumption and mass would be much greater than in the first-mentioned implementation because an embedded computer or digital signal processor would be necessary for processing video data. Design and fabrication of the camera optics would present a challenge, inasmuch as the field of view should, ideally, be 150° wide. The challenge is compounded by the need to avoid reflective optics, which would disrupt the polarization pattern.

• In the most elegant implementation, not yet realized, each pixel of a charge-coupled-device (CCD) camera would be subdivided into three subpixels, each covered with a differently oriented polarization filter. The resulting device would be small and lightweight and would demand little power, but manufacturing would be complex. The basic principle of ocellar horizon sensors was also described in the cited prior article. These sensors are based partly on dragonfly ocelli — simple eyes that exist in addition to the better-known compound eyes of insects and that sense only light, dark, and motion. In dragonflies, the ocelli play an important role in stabilizing attitude with respect to dorsal light levels.

An ocellar horizon sensor of the type under development includes UV/green pairs of photodiodes and utilizes dragonfly-inspired principles of color-oppo-

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