Miniature Wide-Angle Lens for Small-Pixel Electronic Camera

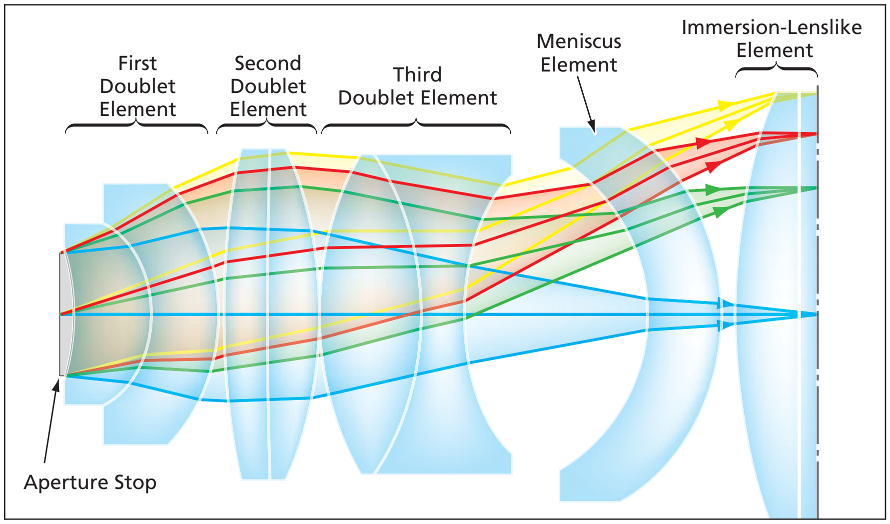
The lens design addresses issues peculiar to small-pixel image sensors.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure depicts a proposed wide-angle lens that would be especially well suited for an electronic camera in which the focal plane is occupied by an image sensor that has small pixels. The design of the lens is intended to satisfy requirements for compactness, high image quality, and reasonably low cost, while addressing issues peculiar to the operation of small-pixel image sensors. Hence, this design is expected to enable the development of a new generation of compact, high-performance electronic cameras. The lens example shown has a 60° field of view and a relative aperture (*f*-number) of 3.2.

The main issues affecting the design are the following:

- The response of a small-pixel image sensor is sensitive to the angle of incidence of the light. At large angles of incidence, the response includes excessive crosstalk among pixels.
- When a lens of typical prior design images a wide field, rays from the edge of the field are typically incident on the image sensor at large angles. This effect can be mitigated by use of a so-called image-space telecentric lens, for which the angle of incidence is constant. However, such a lens is typically much larger than is a comparable non-telecentric lens.
- In the original intended application, in which the lens would be used to focus light on a back-side-illuminated image sensor, there are requirements to minimize the size of the lens while making its optical behavior nearly telecentric, to obtain nearly diffraction-limited image quality while limiting distortion. The following are some key characteristics of the lens design:



This **Optical Layout** shows the main features of the lens design. The total length of the lens from aperture stop to the image plane is less than two times its focal length.

- The lens would include an element that would function like an immersion lens. The image sensor would be mounted in direct contact with this element. The incorporation of this element would enable maximization of the degree of telecentricity by bending rays from the edge of the field proportionately more than those from the middle, while otherwise exerting little effect on performance.
- A first doublet element, comprising two subelements made of glasses characterized by a large difference between their indices of refraction, would be placed immediately after an aperture stop. This doublet would control the field curvature and the color correction.
- A second doublet element made from two glasses that have similar, high indices of refraction but very different dispersion values. This element would control the chromatic correction and provide most of the positive lens power necessary for imaging.
- An "air lens" between a third doublet element and a meniscus element would be used to balance the positive power while affording some correction for aberrations.
- The aperture stop would be located at the front of the lens.
- All of the lens elements and subelements are designed to have spherical surfaces and to be made of commonly used glasses. Hence, the lens could likely be produced at lower cost than would be possible if aspherical shapes or unusual glasses were required.

This work was done by Pantazis Mouroulis and Edward Blazejewski of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-44404

Modal Filters for Infrared Interferometry

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vModal filters in the ≈10-µm spectral range have been implemented as planar dielectric waveguides in infrared interferometric applications such as searching for Earth-like planets. When looking for a small, dim object ("Earth") in close proximity to a large, bright object ("Sun"), the interferometric technique uses beams from two telescopes combined with a 180° phase shift in order to cancel the light from a brighter object. The interferometer baseline can be adjusted so that, at the same time, the light from the dimmer object arrives at the combiner in phase. This light can be detected and its infrared (IR) optical spectra can be studied. The cancellation of light from the