OPTICAL SYSTEM FOR COLLECTING DISTANCE INFORMATION WITHIN A FIELD

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates generally to the field of optical sensors and more specifically to a new and useful optical system for collecting distance information in the field of optical sensors.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention, there is provided an optical system including: a bulk imaging optic having a focal plane; a pixel array comprising a plurality of pixels; and an aperture layer coincident with the focal plane and disposed between the bulk imaging optic and the pixel array, the aperture layer including a plurality of discrete apertures defining a plurality of discrete, non-overlapping fields of view beyond a threshold distance in a field external to the optical system; wherein the aperture layer and pixel array are arranged to form a plurality of sense channels, each sense channel in the plurality of sense channels including a pixel from the pixel array and an aperture from the plurality of apertures that defines a field of view for the sense channel, and wherein each pixel in the plurality of sense channels is electrically coupled to digital processing electronics including a counter and a register.

According to a second aspect of the present invention, there is provided an optical system for performing distance measurements, the optical system including: a bulk transmitter optic; an illumination source comprising a plurality of lasers, each laser in the plurality of lasers configured to project a discrete illuminating beam at an operating wavelength through the bulk transmitter optic into a field external to the optical system; a bulk imaging optic having a focal plane; a lens array including a plurality of lenses; a pixel array comprising a plurality of pixels, wherein each pixel in the plurality of pixels is

electrically coupled to digital processing electronics including a counter and a register; an aperture layer coincident with the focal plane and disposed between the bulk imaging optic and the pixel array, the aperture layer including a plurality of discrete apertures defining a plurality of discrete, non-overlapping fields of view beyond a threshold distance in a field external to the optical system, wherein the aperture layer, lens array and pixel array are arranged to form a plurality of sense channels, each sense channel in the plurality of sense channels including a pixel from the pixel array, a lens from the plurality of lenses, and an aperture from the plurality of apertures that defines a field of view for the sense channel.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic representation of a system.

FIG. 2 is a schematic representation in accordance with one variation of the system.

FIG. 3 is a schematic representation in accordance with one variation of the system.

FIG. 4 is a schematic representation in accordance with one variation of the system.

FIG. 5 is a schematic representation in accordance with one variation of the system.

FIG. 6 is a schematic representation in accordance with one variation of the system.

FIG. 7 is a schematic representation in accordance with one variation of the system.

FIG. 8 is a schematic representation in accordance with one variation of the system.

FIG. 9 is a flowchart representation in accordance with one variation of the system.

FIG. 10 is a schematic representation in accordance with one variation of the system.

CLAIMS

1. An optical system comprising:

a bulk imaging optic having a focal plane;

a pixel array comprising a plurality of pixels; and

an aperture layer coincident with the focal plane and disposed between the bulk imaging optic and the pixel array, the aperture layer including a plurality of discrete apertures defining a plurality of discrete, non-overlapping fields of view beyond a threshold distance in a field external to the optical system;

wherein the aperture layer and pixel array are arranged to form a plurality of sense channels, each sense channel in the plurality of sense channels including a pixel from the pixel array and an aperture from the plurality of apertures that defines a field of view for the sense channel, and wherein each pixel in the plurality of sense channels is electrically coupled to digital processing electronics including a counter and a register.

2. The optical system set forth in claim 1 further comprising a lens array including a plurality of lenses and wherein each sense channel in the plurality of sense channels further includes a lens from the plurality of lenses.

3. The optical system set forth in either of claims 1 or 2 wherein a sensing area of each pixel in the plurality of sense channels is larger than an area of the aperture with which the pixel shares a sense channel.

4. The optical system set forth in claim 3 wherein each pixel in the plurality of sense channels comprises a plurality of single-photon avalanche diode detectors (SPADs).

5. The optical system set forth in claim 4 wherein each SPAD is electrically coupled to digital processing electronics including a counter and a register

6. The optical system set forth in any of claims 4 to 5 further comprising, within each sense channel, a diffuser configured to spread light from each channel across the plurality of SPADs within the channel.

7. The optical system of claim 1 wherein the aperture layer comprises a thin opaque structure arranged along the focal plane of the bulk imaging optic.

8. The optical system of claim 1 wherein adjacent apertures in the aperture layer are offset by an aperture pitch distance greater than a diameter of each aperture.

9. The optical system set forth in claim 1 wherein each pixel in the plurality of sense channels is configured to output a signal or stream of signals corresponding to a count of photons incident on the pixel within a sampling period.

10. The optical system set forth in any of claims 1 to 9 further comprising an optical filter disposed, within each sense channel, between the bulk imaging optic and the pixel array, the optical filter configured to receive light passed through the bulk imaging optic and pass a narrow band of radiation to a pixel within the sense channel while blocking radiation outside the band.

11. The optical system set forth in claim 10 wherein the system is configured to perform distance measurements and further comprises:

a bulk transmitter optic; and

an illumination source comprising a plurality of emitters, each emitter in the plurality of emitters configured to project a discrete illuminating beam at an operating wavelength through the bulk transmitter optic into the field external to the optical system; and

wherein the optical filter within each sense channel is configured to pass a band of wavelengths of light including the operating wavelength while blocking light outside the band and each of the plurality of pixels is configured to receive light from a corresponding one of the plurality of emitters.

12. The optical system set forth in claim 11 wherein the illumination source comprises a plurality of lasers.

13. The optical system of claim 12 wherein the plurality of lasers are arranged in an array and configured to project a plurality of discrete illuminating beams in a field ahead of the optical system according to an illumination pattern that substantially matches, in size and geometry across a range of distances from the system, the plurality of discrete, non-overlapping fields of view of the plurality of sense channels.

14. The optical system set forth in claim 12 wherein the plurality of lasers are a monolithic vertical cavity surface emitting laser (VCSEL) array.

15. The optical system set forth in any of claims 11 to 14 wherein the system is configured to function as an image sensor that, when rotated about an axis parallel to a column of apertures, collects three-dimensional distance data that can be reconstructed into a virtual three-dimensional representation of a volume occupied by the system.

16. An optical system for performing distance measurements, the optical system comprising:

a bulk transmitter optic;

an illumination source comprising a plurality of lasers, each laser in the plurality of lasers configured to project a discrete illuminating beam at an operating wavelength through the bulk transmitter optic into a field external to the optical system;

a bulk imaging optic having a focal plane;

a lens array including a plurality of lenses;

a pixel array comprising a plurality of pixels, wherein each pixel in the plurality of pixels is electrically coupled to digital processing electronics including a counter and a register;

an aperture layer coincident with the focal plane and disposed between the bulk imaging optic and the pixel array, the aperture layer including a plurality of discrete apertures defining a plurality of discrete, non-overlapping fields of view beyond a threshold distance in a field external to the optical system, wherein the aperture layer, lens array and pixel array are arranged to form a plurality of sense channels, each sense channel in the plurality of sense channels including a pixel from the pixel array, a lens from the plurality of lenses, and an aperture from the plurality of apertures that defines a field of view for the sense channel.

17. The optical system of claim 16 wherein a sensing area of each pixel in the plurality of sense channels is larger than an area of its corresponding aperture in the plurality of apertures.

18. The optical system of claim 17 wherein each pixel in the pixel array comprises a plurality of SPADs distributed across its sensing area.

19. The optical system of any of claims 16 to 18 further comprising, within each channel in the plurality of sense channels, an optical filter disposed between the bulk receiving optic and the array of pixels, the optical filter configured to receive light passed through the bulk receiving optic and pass a narrow band of radiation while blocking radiation outside the band.

20. The optical system of claim 19 wherein each laser in the plurality of lasers is a VCSEL.