US010371928B2

(12) **United States Patent**
Goldenberg et al.

(10) **Patent No.: US 10,371,928 B2**
(45) **Date of Patent: Aug. 6, 2019**

(54) **AUTO FOCUS AND OPTICAL IMAGE STABILIZATION IN A COMPACT FOLDED CAMERA**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/289,669**

(22) Filed: **Mar. 1, 2019**

(65) **Prior Publication Data**

US 2019/0196156 A1 Jun. 27, 2019

Related U.S. Application Data

(63) Continuation of application No. 15/917,701, filed on Mar. 11, 2018, which is a continuation of application
(Continued)

(51) **Int. Cl.**
G02B 27/64 (2006.01)
G02B 13/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***G02B 13/0065*** (2013.01); ***G02B 7/08*** (2013.01); ***G02B 7/09*** (2013.01); ***G02B 13/16*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC G02B 7/04; G02B 27/64; G02B 27/646; H04N 5/23248; H04N 5/23264; H04N 5/2328; H04N 5/23287
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,199,785 A 4/1980 McCullough et al.
5,005,083 A 4/1991 Grage et al.
(Continued)

OTHER PUBLICATIONS

Statistical Modeling and Performance Characterization of a Real-Time Dual Camera Surveillance System, Greienhagen et al., Publisher: IEEE, 2000, 8 pages.
(Continued)

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(57) **ABSTRACT**

Compact folded camera modules having auto-focus (AF) and optical image stabilization (OIS) capabilities and multi-aperture cameras including such modules. In an embodiment, a folded camera module includes an optical path folding element (OPFE) for folding light from a first optical path with a first optical axis to a second optical path with a second optical axis perpendicular to the first optical axis, an image sensor and a lens module carrying a lens with a symmetry axis parallel to the second optical axis. The lens module can be actuated to move in first and second orthogonal directions in a plane perpendicular to the first optical axis, the movement in the first direction being for auto-focus and the movement in the second direction being for OIS. The OPFE can be actuated to tilt for OIS.

20 Claims, 14 Drawing Sheets