

Advanced IR Zoom Lenses for Next Generation Thermal Imaging Applications



Kobi (Jacob) Lasri, Ophir Optronic Solutions Ltd.

Abstract: In this paper we review recent advances in the development of infrared zoom lenses that meet challenging requirements for reduced Size, Weight, and Power (SWaP) while enabling high-resolution vision and identification in harsh environmental conditions and constrained platforms such as airborne and portable systems. The design considerations and performance of advanced folded-optics and lightweight zoom lenses optimized for next generation infrared thermal imaging systems and applications are described.

1. INTRODUCTION

Infrared imaging applications are evolving at a rapid pace and continue to drive challenging requirements for reduced Size, Weight, and Power (SWaP). In particular, applications like Hand Held Thermal Imagers (HHTI), UAV, and small gimbals present a growing need for advanced, high-performance, IR thermal imaging systems with reduced size and weight. While advances in detector resolution should improve imaging performance, this is impossible without an accompanying improvement in the quality of the IR optical lens assembly. Specifically, in optics-limited systems, lens quality is playing a major role in determining the imaging performance, even with the best detector. The challenge falls on lens providers to design and produce compact, lightweight lenses with a crisp clean image over the entire zoom range and an MTF close to the diffraction limit. In this vein, various technologies are being used to meet these optical needs, including innovative opto-mechanical designs^[1],

exotic materials^[2,3], and free-form optics^[4]. In this paper we demonstrate advanced designs of two continuous IR zoom lenses with reduced SWaP based on unique folded-optic and lightweight opto-mechanical concepts, respectively, suitable for next generation IR cooled detector and thermal imaging applications with constrained platforms.

2. CONTINUOUS ZOOM LENS SWAP DESIGNS

Two examples of SWaP zoom lenses for cooled MWIR IR sensors are described. The first is a 16-180mm f/3.6 continuous zoom lens in a folded-optic configuration suitable for compact gimbaled payloads with 10 μ m pixel cooled detectors. The second SWaP example is a 20-275mm f/5.5 continuous zoom lens with a unique light-weight opto-mechanical design suitable for UAVs, drones, and HHTI applications.

2.1. Folded-Optic 16-180mm f/3.6 Zoom Lens Design

Figure 1(a) demonstrates the opto-mechanical layout and picture of the 16-180mm f/3.6 zoom lens optimized for MWIR 10 μ m pixel detectors. The design is based on a standard relay and objective configuration with two moving groups that allow for the change in the focal length. The materials were selected using best practices, as well as the athermalization and achromatization concepts.

The characteristics of this lens lead to long operational ranges relative to the lens size and weight. For example, the detection range of a 2.3m vehicle would be around 15km(!) when integrated with a 23mK NETD, 15 μ m pixel detector (based on FLIR92 model calculations). To the best of our knowledge, this is the smallest and lightest continuous zoom lens on the market today enabling such high-performance capabilities of advanced IR thermal imaging systems in harsh environmental conditions and constrained platforms.

3. SUMMARY

We have successfully designed and implemented advanced IR zoom lenses with reduced SWaP which are based unique folded-optic design suitable for 10 μ m pixel size, as well as lightweight opto-mechanical concept that enabled over 40% weight reduction. In both lenses we have demonstrated MTF performance close to the diffraction limit and capabilities for high-resolution vision and identification in harsh environmental conditions and constrained platforms. Such zoom lenses open-up new opportunities in next generation UAV, HHTI, and small gimbals thermal imaging applications.

REFERENCES

1. J.L. Ramsey et al., "Experimental verification of a MWIR/LWIR 3x continuous zoom lens", Proc. SPIE 10998, 109980M1-6 (2019).
2. G. Beadie et al., "Temperature-dependent dispersion fitting for a recent infrared glass catalog", Proc. SPIE 10998, 10998041-6 (2019).
3. D. Gibson et al., "Multispectral IR optics and GRIN", Proc. SPIE 10998, 109980D1-10 (2019).
4. S. Szapiel et al., "Freeform based lateral-shift compact zoom system: theory and computer simulations", Proc. SPIE 10627, Advanced Optics for Defense Applications: UV through LWIR III, 1062707 (May 2018).