Yuying WANG, Jindong LI, Hezhi SUN, Xiang LI, 2024. A review on the developments and space applications of mid- and long-wavelength infrared detection technologies. *Frontiers of Information Technology & Electronic Engineering*, 25(8):1031-1056. https://doi.org/10.1631/FITEE.2300218

A review on the developments and space applications of mid- and long-wavelength infrared detection technologies

Key words: Infrared detection; Space application; Mid- and long-wavelength infrared detection; Space-based Earth observation; Remote sensing

Corresponding author: Jindong LI
E-mail: ljdcast@163.com
ORCID: https://orcid.org/0009-0006-5774-212X

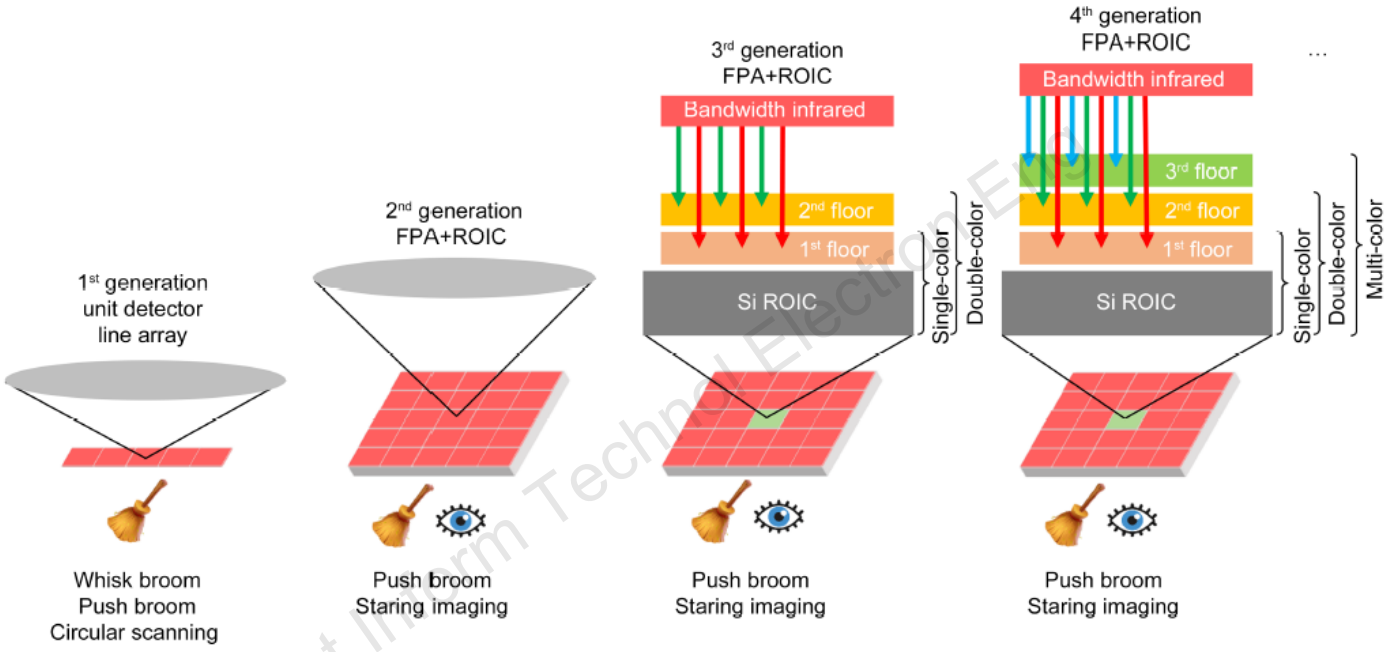
Motivation

- Mid-wavelength infrared (MWIR) detection and long-wavelength infrared (LWIR) detection constitute the key technologies for space-based Earth observation and astronomical detection. The advanced ability of infrared (IR) to penetrate the atmosphere and identify the camouflaged targets makes it essential for detecting and tracking low-temperature and far-distance moving targets.
- However, due to the diverse scenarios in which space-based IR detection systems are built, the key parameters of IR technologies are subject to unique demands. Thus, it is crucial to provide a more comprehensive exposition of the applications, developments, requirements, and challenges of IR detection technologies.

Main idea

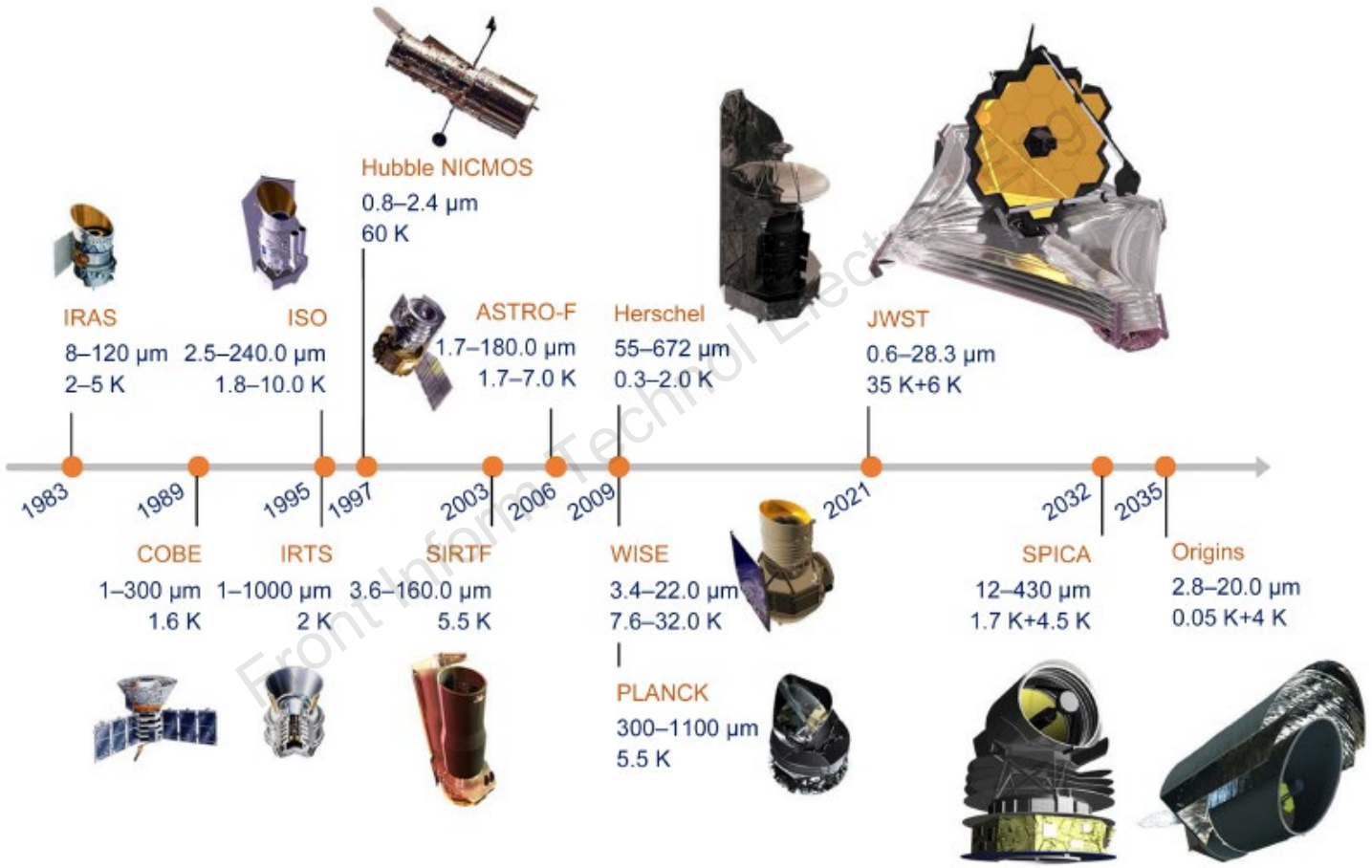
- The developments and features of MWIR and LWIR detectors with a particular focus on their applications in space-based detection are reviewed.
- A comprehensive analysis of key performance indicators for IR detection systems and their interconnections with IR detector parameters are conducted.
- The influences of pixel distance, focal plane array size, and operation temperature of space-based IR remote sensing are evaluated. Requirements and technical challenges of MWIR and LWIR detection systems are identified to achieve high-quality space-based observation platforms.

Evolution and space-based applications of infrared detectors



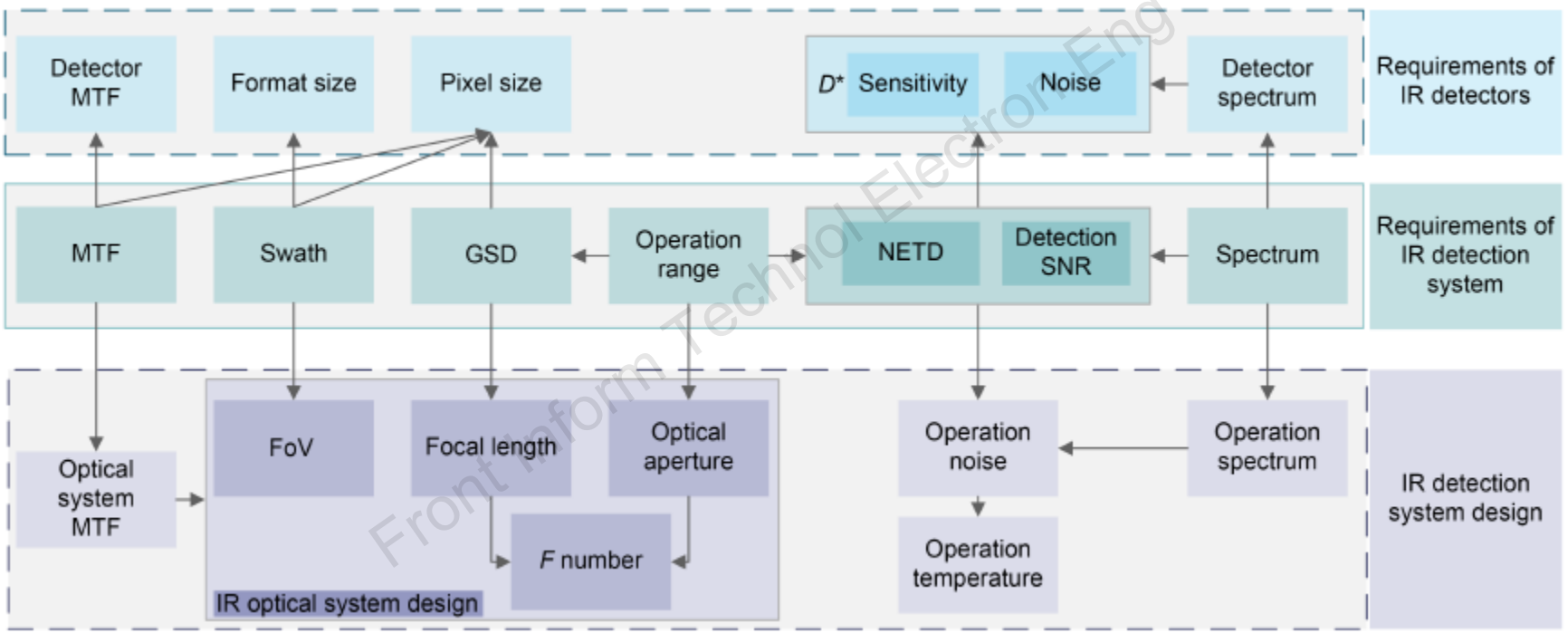
IR detectors have evolved from unit detectors, line arrays, single-color FPAs, and double-color FPAs to the current 4th generation, which features multi-color FPAs. As the number of pixels significantly increases, staring imaging is enabled.

Development of cooled infrared systems onboard space telescopes



Onboard the high-performance IR astronomy observation telescopes, high-sensitivity IR detectors operate at temperatures ranging from 0.3 to 60 K, covering the detection range from SIR to FIR.

Interconnections between the performance indicators of infrared detectors and detection systems



The relationships between key performance indicators in designing a space-based IR detection system are summarized. One can discern how an IR detector characteristic impacts the performance indicators of the IR detection system and determine the design parameters required to meet the IR detection system specifications.

Conclusions

Future IR detectors should have detection spectrum that expands to mid-wavelength and long or very long wavelength, with a large integrated format size and a smaller pixel size. This will enable the space detection capability and the ability to explore the margins of space, and will support future space resource exploration and space policy formulation as well.

It is expected that in the future, a new generation of IR detectors with multi-dimensional information fusion imaging, on-chip intelligence, and on-chip sensing-storage-processing features will further enhance IR detector technologies.

Jindong LI, professor of China Academy of Space Technology, academician of China Academy of Engineering. His research interests include spacecraft system engineering.

Yuying WANG works in Beijing Institute of Spacecraft System Engineering, China Academy of Space Technology. Her research interests include spacecraft system engineering, intelligent sensing, and spacecraft thermal control.

Hezhi SUN works in China Academy of Space Technology. His research interests include satellite optical remote sensing, remote sensing image processing, and space electric propulsion technology.

Xiang LI works in China Academy of Space Technology. His research interests include infrared remote sensing and spacecraft system engineering.