360° snapshot imaging with a convex array of long-wave infrared cameras

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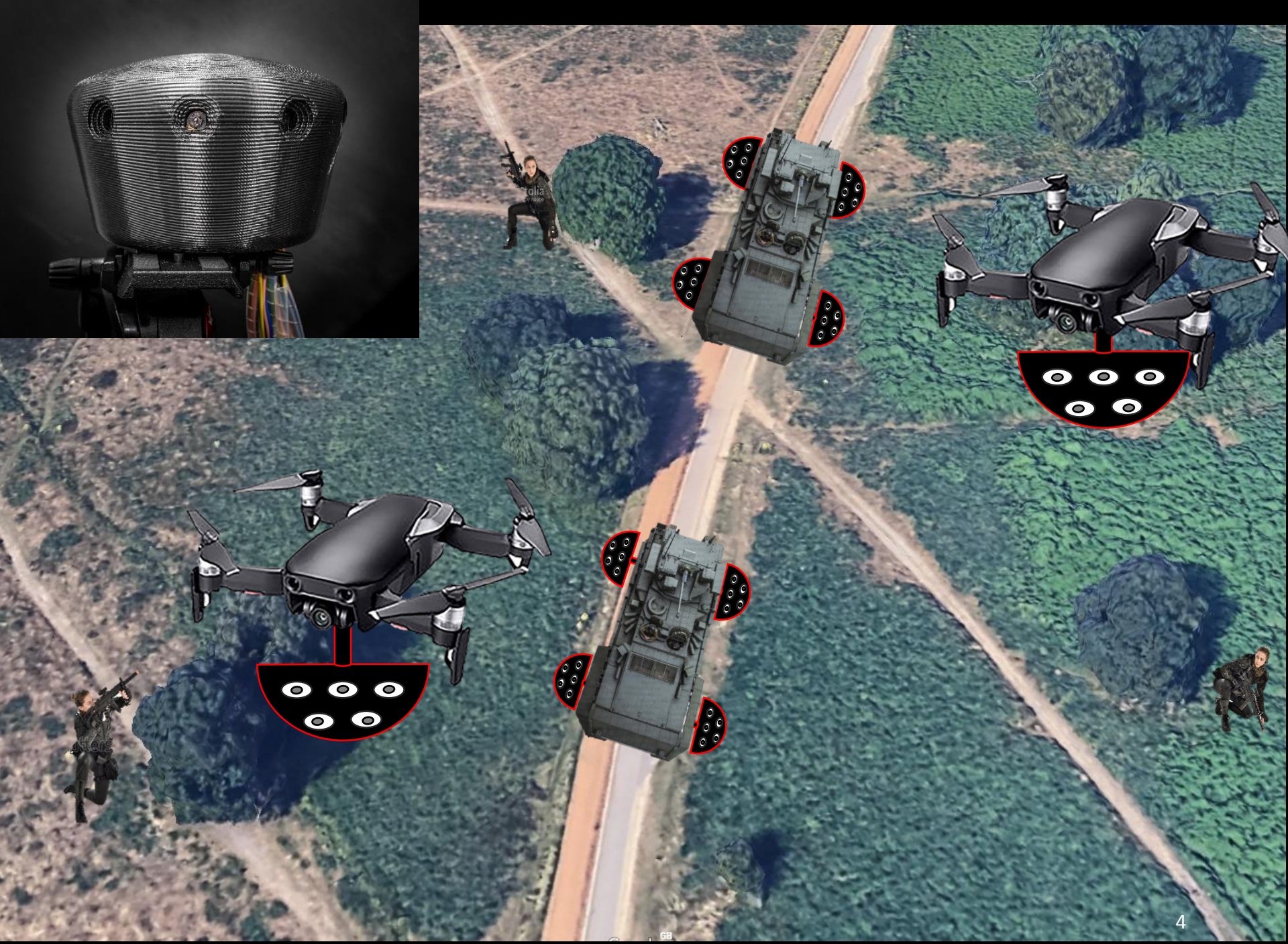
Q: If we use the soldiers helmet as a 360^{o} panoramic imager, what information can we gather ?

What we have done:

Answer:

- 360 Situational Awareness
- Passive Ranging
- Super Resolution
- Imaging through obscurants

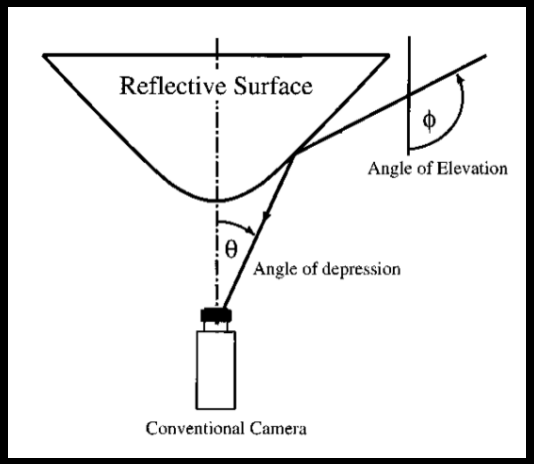


A scalable arrangement of low-cost infrared cameras that can be used to immersively image a scene.

Presentation Outline

- Context and big picture application
- Traditional approaches to panoramic imaging
- 360^{o} Infrared Panoramic Imager
- Other modalities of the Imager
- Review and Conclusion

Traditional approaches to Panoramic imaging



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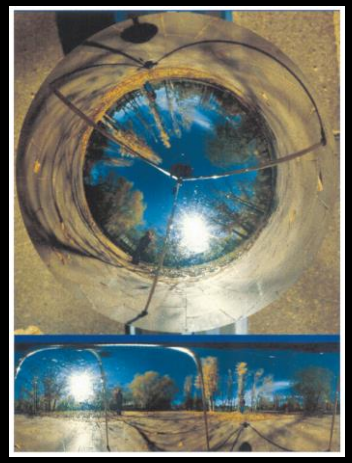


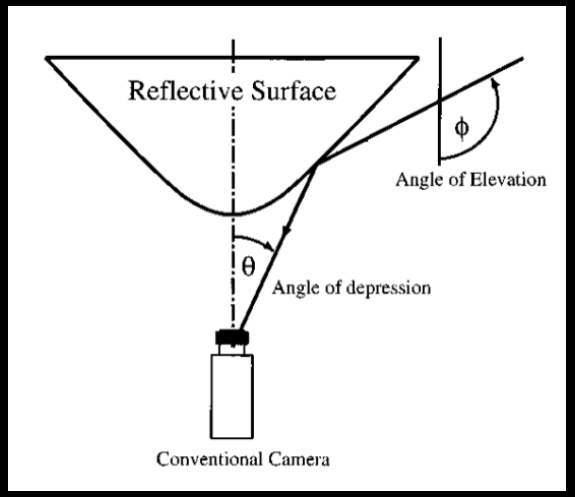
[1]

[2]

- Total Pixel count limited by detector
- Trade field-of-view for angular resolution
- Optical aberrations limit resolution
- Optical aberrations increase lens complexity, size, weight, cost

[1] Chahl and Srinivasan, Appl Optics (1997).
[2] Pernechele, Opt. Express (2016).

Curved Detector Array



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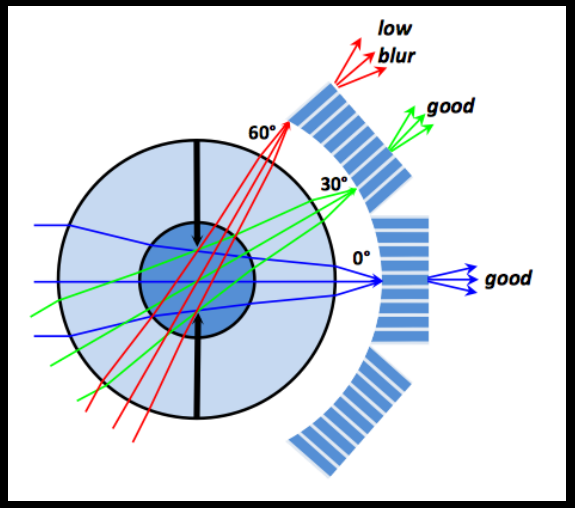

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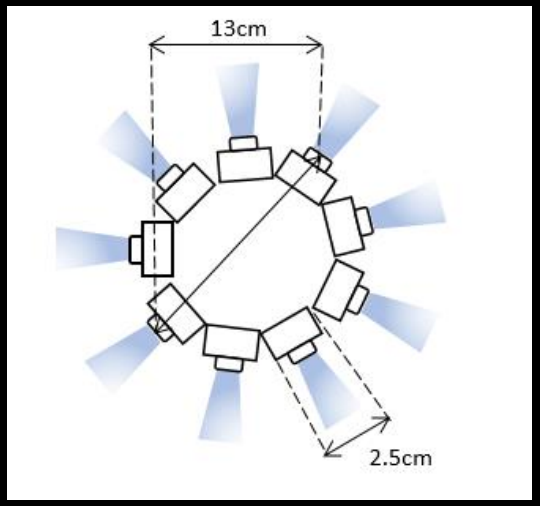
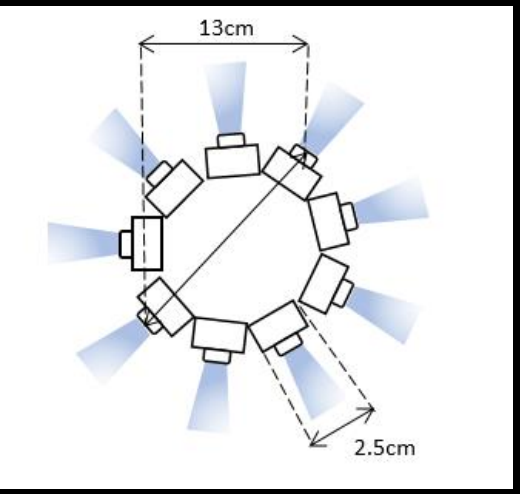


- Curved detector reduces optical aberrations and enables simpler optics
- Can be achieved by using single or multiple detectors.
  - Multiple cameras mean scalable architecture, no longer limited by detector pixel count
  - Multiple Cameras reduce aberrations
  - Multiple cameras allow for versatile modalities and parallelized imaging

[1] Chahl and Srinivasan, Appl Optics (1997)
[2] Stamenov et al, Opt. Express (2014)

360° Panoramic Imager



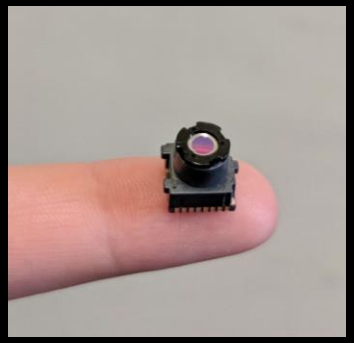


PHOTO: KEVIN. J. MITCHEL

- 9 low-cost LWIR (8-12µm) 50° FOV FLIR Lepton cameras in convex array
  - Each camera 80x60 pixels
  - 17µm pixels
  - Silicon lens replaces expensive germanium lens.
- Powered by a Raspberry Pi
- Snapshot imaging

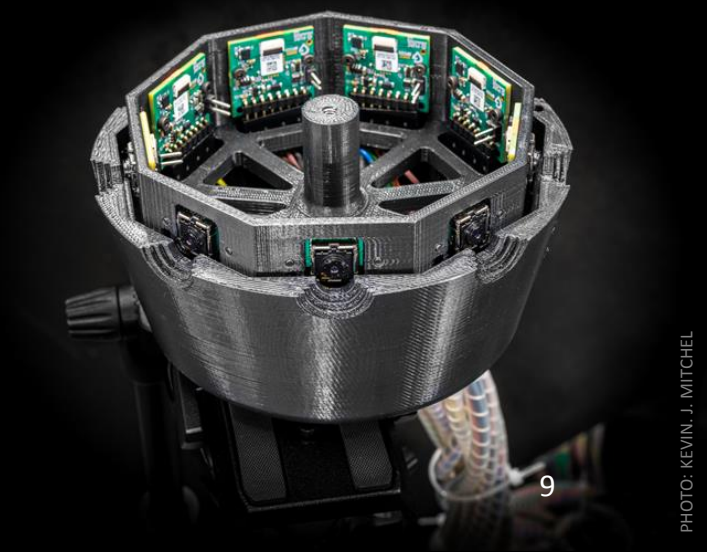
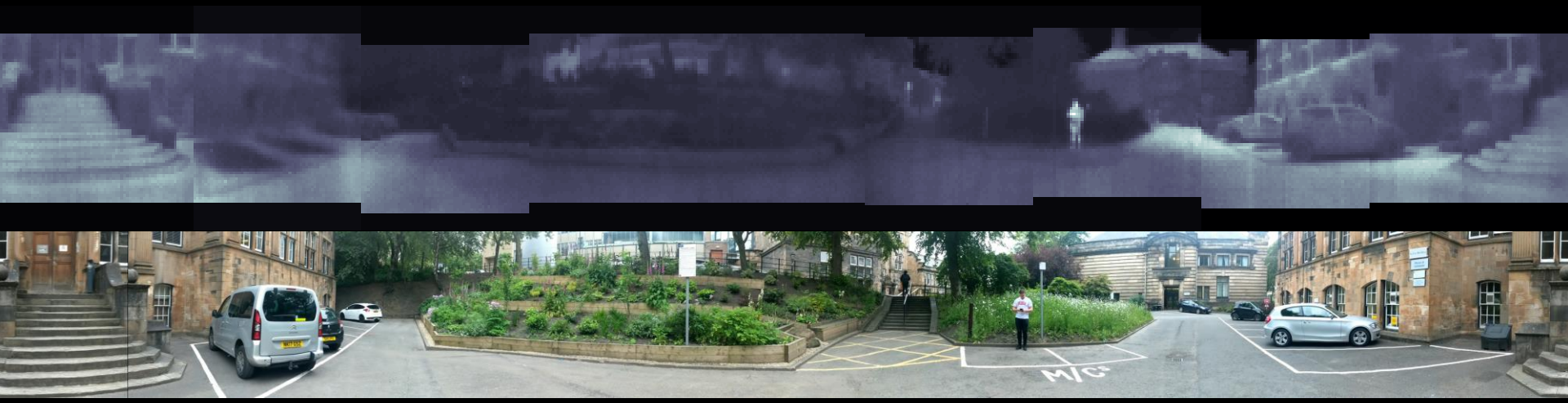


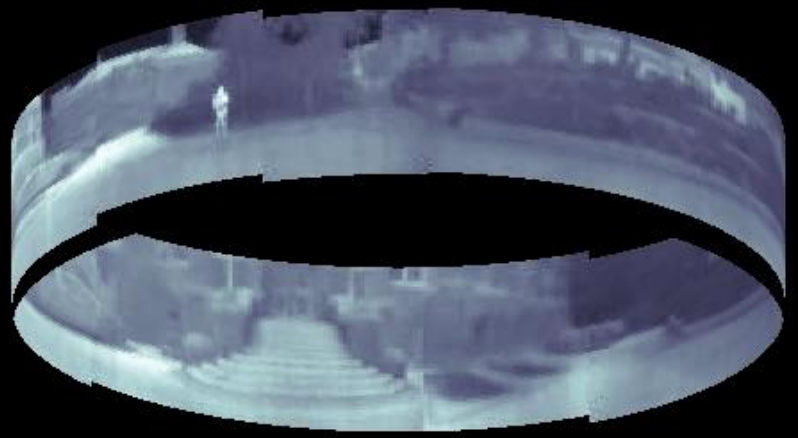
PHOTO: KEVIN. J. MITCHEL

Panoramic Images and Videos



link to interactive panoramic video…
https://youtu.be/BiIq44osxIo

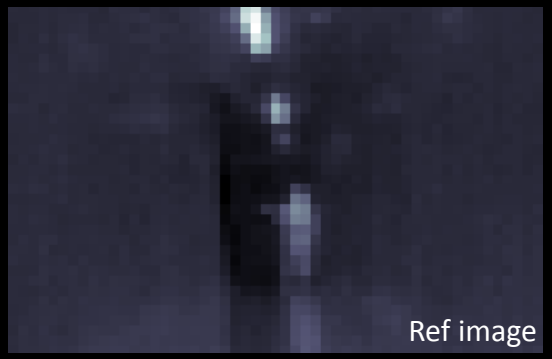
Scan me

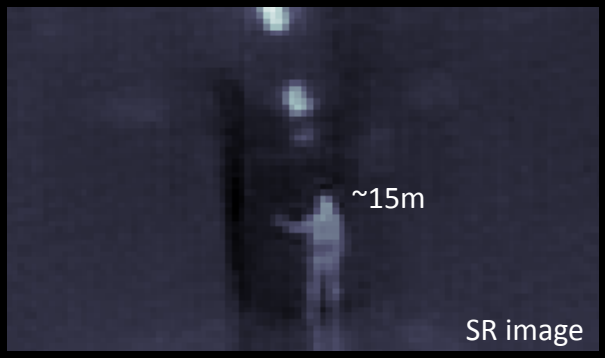


Other Modalities

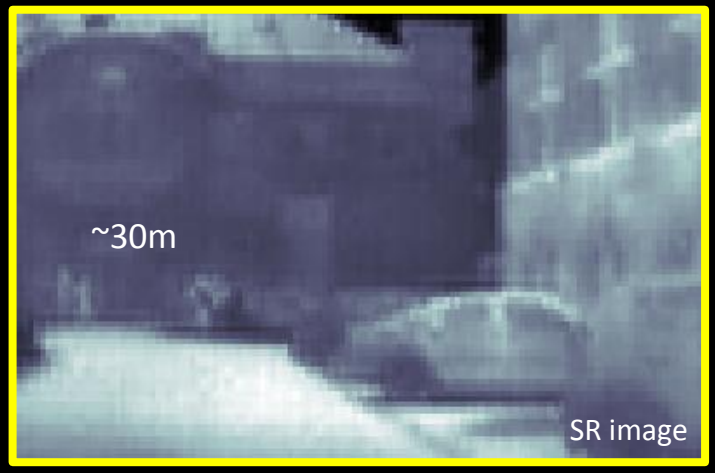
- Super resolution
- Passive ranging
- Imaging through obscurants

Time sequential super resolution

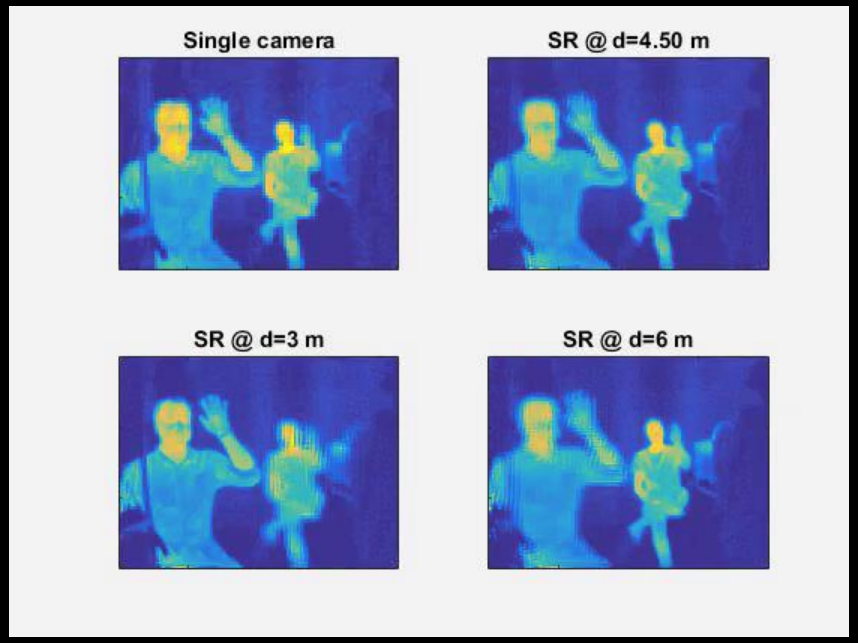


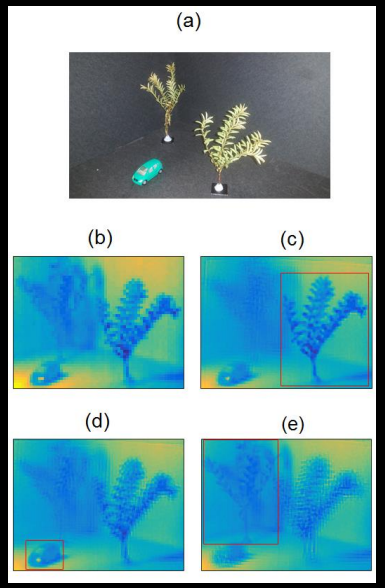


- Natural Jitter from handheld imager
- Lepton (50^{o} FOV) pixel size is 17µm which undersamples a a LWIR scene, allowing the scene to be aliased.
- Ability to super resolve the scene by a factor of 2 in X and Y.



Passive Ranging and imaging through obscurants

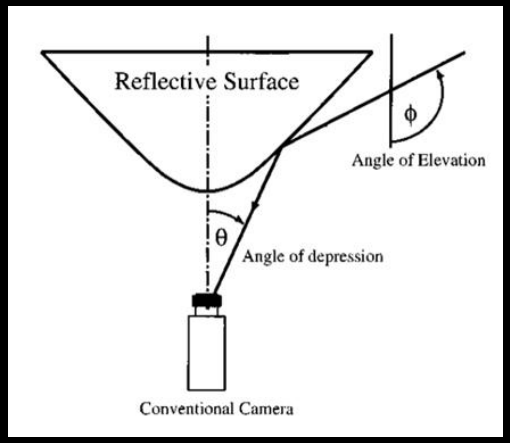




- Passive Ranging from disparity
  - Baseline between cameras is 4.5cm, give disparity of 0.5 pixels at 7m. Footstep could create baseline of 1m, allowing passive ranging of ~800m
- Imaging through obscurants
  - Super resolution sensitive to distance of registration

[1] Miguel A. Preciado, Guillem Carles, and Andrew R. Harvey, "Video-rate computational super-resolution and integral imaging at longwave-infrared wavelengths," OSA Continuum1, 170-180 (2018)

Review and Conclusion



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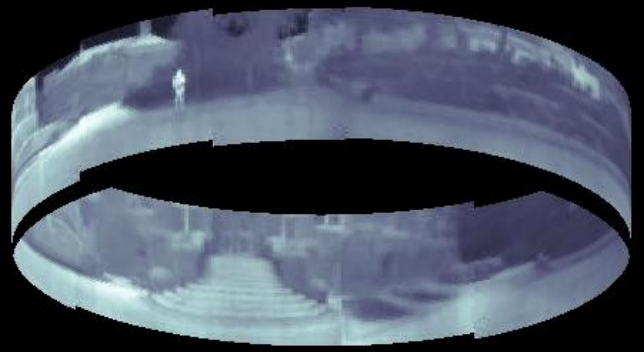

- Traditional approaches to panoramic imaging
  - Highly aberrated images and complex optics
- Curved Detector array and parallelised imaging
  - Reduction of complexity and aberrations
  - Snapshot imaging
- 360^{o} Panoramic imager
  - Scalable architecture
- Versatile modalities
  - Super resolution and passive ranging

[1] J. S. Chahl and M. V. Srinivasan, "Reflective surfaces for panoramic imaging," Appl Optics (1997)

Thank you for your attention

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