360º infrared imager with scalable architecture

Laura Cowan [1], James Babington [2], Guillem Carles [1], Andy Wood [2], Andrew R. Harvey [1]

[1] School of Physics and Astronomy ,University of Glasgow , Glasgow, G12 8QQ, UK [2]Qioptiq Ltd, Denbighshire, LL17 0LL, UK

Photocredit: redfoxinict on VisualHunt.com / CC BY

Visualisation of possible application of 360º imager.

Replacing a traditional panoramic imaging system with a multi-aperture array which when integrated with computational imaging techniques, creates a versatile and adaptable system. This convex array of 9 long-wave infrared cameras enables 360º situational awareness, active and passive ranging, computational super resolution and the ability to image through obscurations.

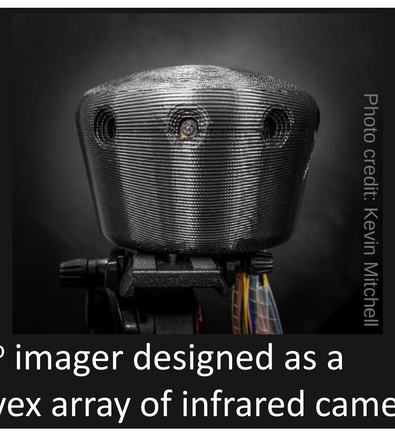
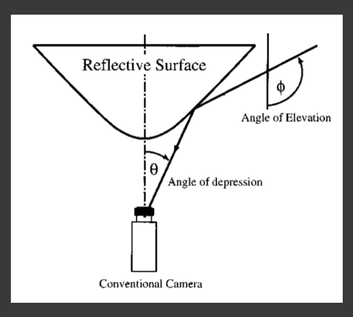


Photo credit: Kevin Mitchell

360º imager designed as a convex array of infrared cameras

Traditional Panoramic Imaging



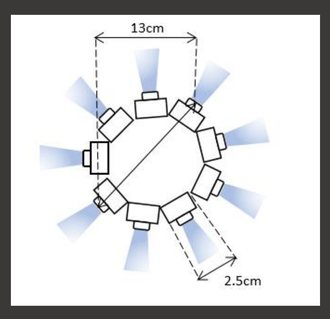
[1]

A traditional panoramic imaging setup using a reflection optic.

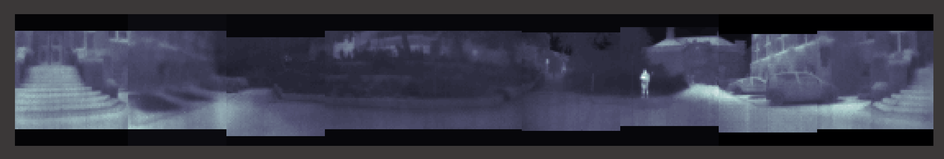
[1]

The distorted output from traditional panoramic imaging system

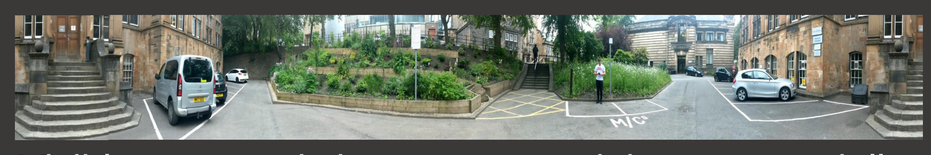
Multi-aperture Panoramic Imaging



The system we have developed for 360º imaging.



Infrared panoramic image captured with the 360º imager

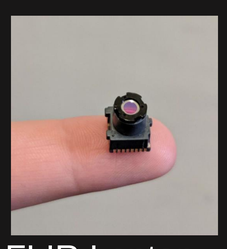


[2]

Visible panoramic image captured time sequentially on mobile phone.

Traditional Panoramic Imaging	Multi-aperture Panoramic Imaging
Trade Field-of-View for angular resolution	Scalable architecture, no longer limited by single detector pixel count
Total pixel count limited by single detector	Multiple cameras reduce aberrations
Optical aberrations limit resolution	Curved detector reduces optical aberrations and enables simpler optics
Optical aberrations increase lens complexity, size, weight and cost.	Versatile Modalities such as; computational super resolution, passive ranging, 3D scene reconstruction and imaging through obscurations

- Off-the-shelf components
- 9 low-cost LWIR FLIR Lepton cameras
- 80x60 pixels, 17µm pixel size
- Silicon lens replaces expensive germanium lens.
- Raspberry Pi



FLIR Lepton Microbolometer

Photo credit: Kevin Mitchell

Real-world Applications

Photo credit: Rocket Scientist 68 on VisualHunt.com / CC BY

Infrared 360º mapped onto a torus. QR code with a link to a virtual reality video. Possible applications of this technology.

Super Resolution

- Natural Jitter from handheld imager
- Lepton under samples a long-wave infrared scene.
- Super resolve the scene by a factor of 2.

Raw image. Cannot easily recognise or Identify objects in scene

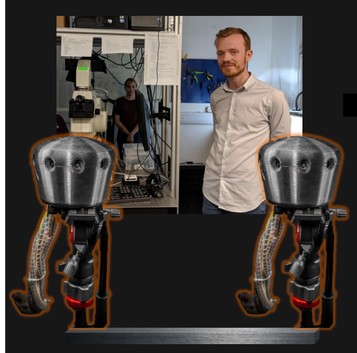
Super resolved image. Can identify man in scene.

Imaging through Obscurations

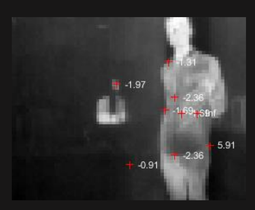
[3]

- Current work in progress
- Integral imaging techniques can be used to image through obscurations such as bushes.
- This is currently being developed for the 360º imager.

Passive Ranging for 3D scenes



- Active baseline so the range is arbitrary.



- Current work in progress
- Active ranging single photon avalanche diode component to be integrated for greater precision

References
[1] J. S. Chahl and M. V. Srinivasan, "Reflective surfaces for panoramic imaging," Appl Optics (1997)
[2] L. V. Cowan et al, “360° snapshot imaging with a convex array of long-wave infrared cameras.” Computational Optical Sensing and Imaging (2019).
[3] Vaish V, Wilburn, et al, “Using plane+ parallax for calibrating dense camera arrays.” CVPR (2004)

Contact
Laura Cowan
laura.cowan@glasgow.ac.uk
School of Physics and Astronomy
University of Glasgow, UK