CEOI SuperRes-EO: Super-resolution restoration from multi-angle EO imagery

Yu Tao, Jan-Peter Muller
UCL-MSSL

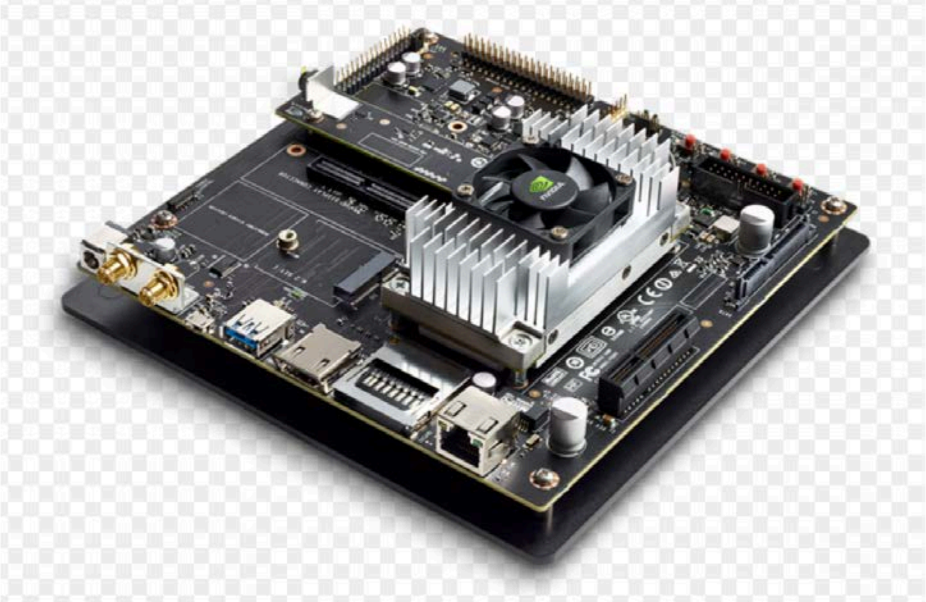
An Overview

- Background and context
- Methods
- Datasets
- Results
- Conclusions

Background and context

- A Super-Resolution Restoration (SRR) algorithm has been developed previously for application to Mars orbital & rover images.
- SRR was applied to NASA MRO HiRISE (25cm) repeat-pass images to yield resolution enhancements of between 2-5 times (i.e. 5-12.5cm).
- CEOI SuperRes-EO aims to develop this existing GPT-SRR system to be applied to EO data including Deimos-2 and Carbonite-2 data.
- Several machine learning and deep learning features have been integrated into the new MFCNN-GPT-GAN (MAGiGAN) system:
  - Mutual Shape Adapted (MSA) Features from Accelerated Segment Test (FAST) with Convolutional Neural Network (CNN) descriptors –
  - Adaptive Least Squares Correlation (ALSC) with region growing (Gotcha) and
  - 4^{th} order Partial Differential Equation (PDE) based Total Variation (TV) –
  - with Generative Adversarial Network (GAN) refinement.
- The MAGiGAN system has been ported onto the NVIDIA Jetson TX-2 GPU board.

NVIDIA Jetson TX-2 GPU board

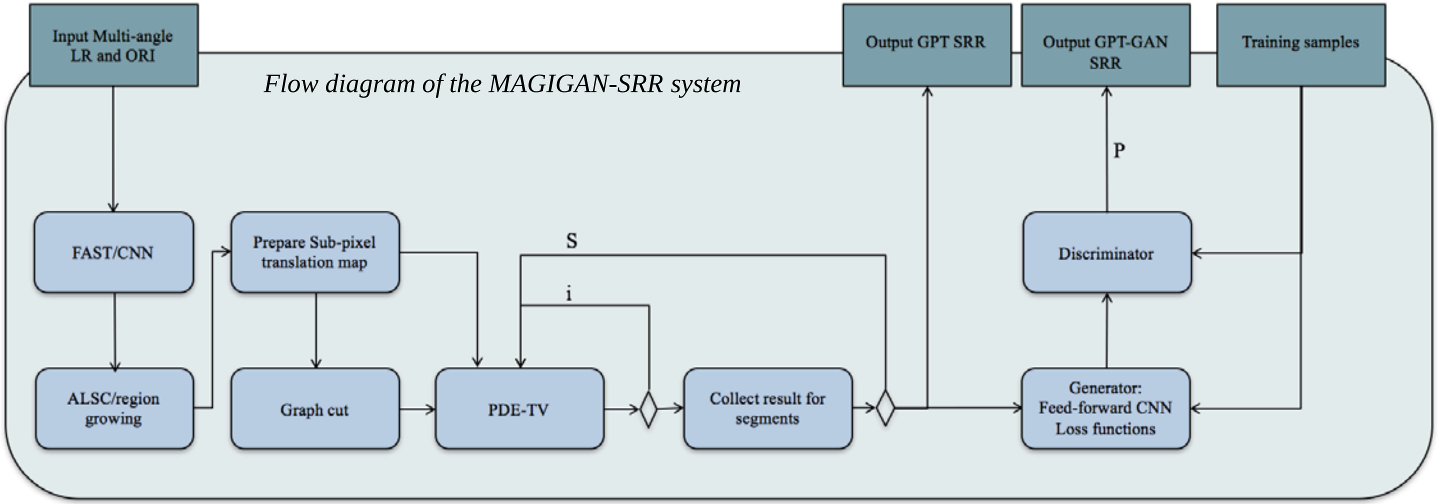


	Jetson TX2
GPU	NVIDIA Pascal™, 256 CUDA cores
CPU	HMP Dual Denver 2/2 MB L2 + Quad ARM® A57/2 MB L2
Video	4K x 2K 60 Hz Encode (HEVC) 4K x 2K 60 Hz Decode (12-Bit Support)
Memory	8 GB 128 bit LPDDR4 59.7 GB/s
Display	2x DSI, 2x DP 1.2 / HDMI 2.0 / eDP 1.4
CSI	Up to 6 Cameras (2 Lane) CSI2 D-PHY 1.2 (2.5 Gbps/Lane)
PCIE	Gen 2 | 1x4 + 1x1 OR 2x1 + 1x2
Data Storage	32 GB eMMC, SDIO, SATA
Other	CAN, UART, SPI, I2C, I2S, GPIOs

Space qualified by ESA, academic cost ≈£305

The MAGiGAN method

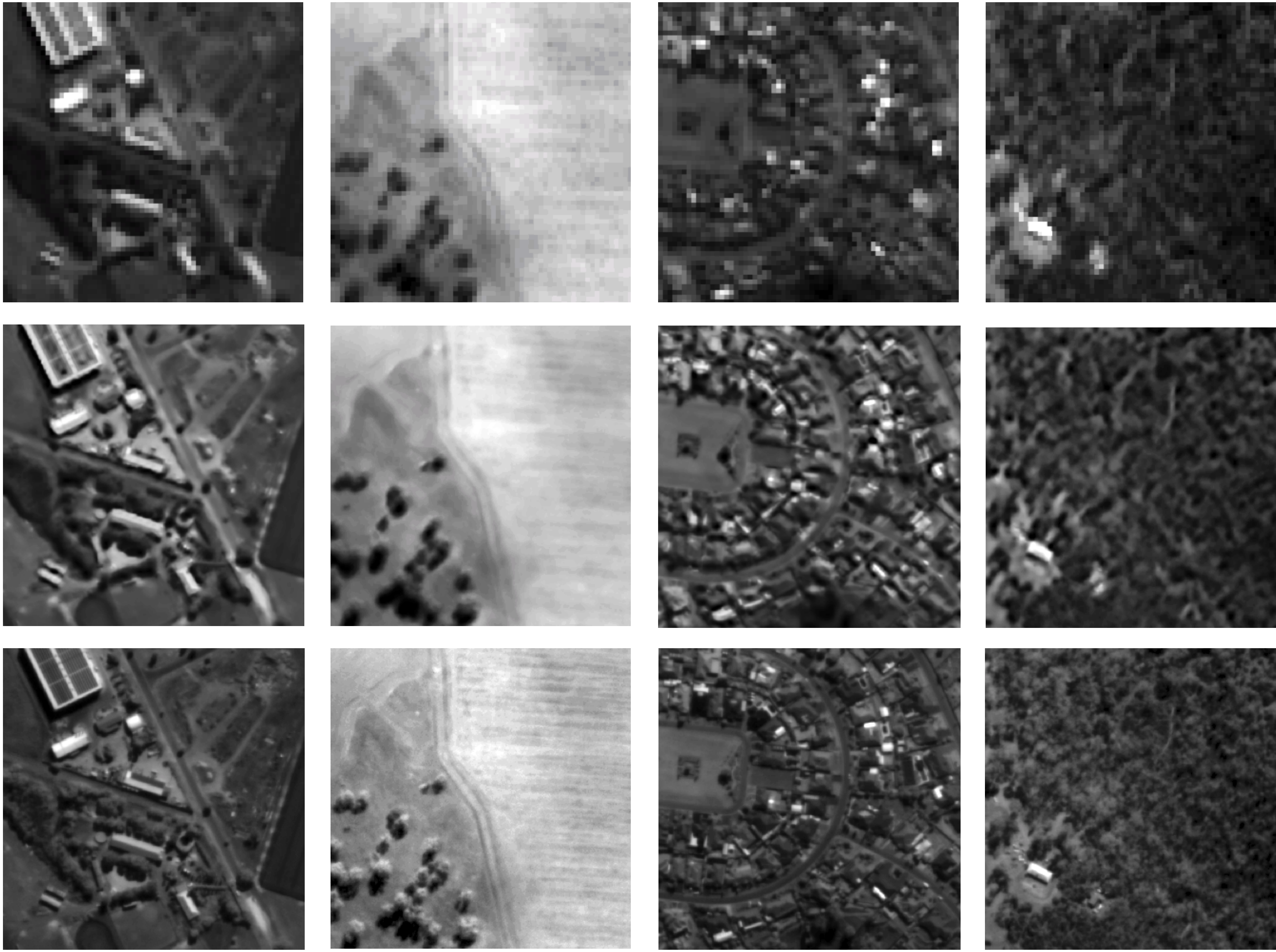
- Sub-pixel motion vectors (down to 0.01 pixel) use Mutual Shape Adapted Features [***Tao & Muller, Icarus, 2016***] from Accelerated Segment Test (MSA-FAST) with Convolutional Neural Network descriptors and Adaptive Least Squares Correlation (ALSC) and region growing (Gotcha) [***Shin & Muller, PR, 2012***].
- Resolves 4th order Partial Differential Equation (PDE) based Total Variation (TV) prior in segmented tiles and collects the results for all high resolution segments to reconstruct the SRR image at finer resolution [***Tao & Muller, PSS, 2016***].
- The **GPT**-SRR technique is optimal for orbital imagery because it not only uses marginal information from pixel shifting (limited to 1.75x enhancement) but also restores distorted features onto an ortho-rectified grid from comparatively large viewing angles [***Tao & Muller, ISPRS, 2016***].
- The GPT-SRR result is further processed using a Generative Adversarial Network (**GAN**) to restore high frequency information learnt from training samples. [***Tao & Muller, SPIE, 2018***].



Test Datasets

- Training datasets for Deimos-2:
  - 102 MS green band images forming 18,782 LR (size 256*256) training samples (discarding bad scenes)
  - 102 PAN band images forming 18,782 HR (size 1024*1024) training samples (discarding bad scenes)
- Test input datasets for Deimos-2:
  - Used 8 (out of 9) images for Adelaide site
- Training datasets for Carbonite-2:
  - 17 green band non-repeat images forming 1,648 LR (size 256*256) training samples
- Test input datasets for Carbonite-2:
  - Used 15 (out of 180) images for Guildford site

Deimos-2 Adelaide site

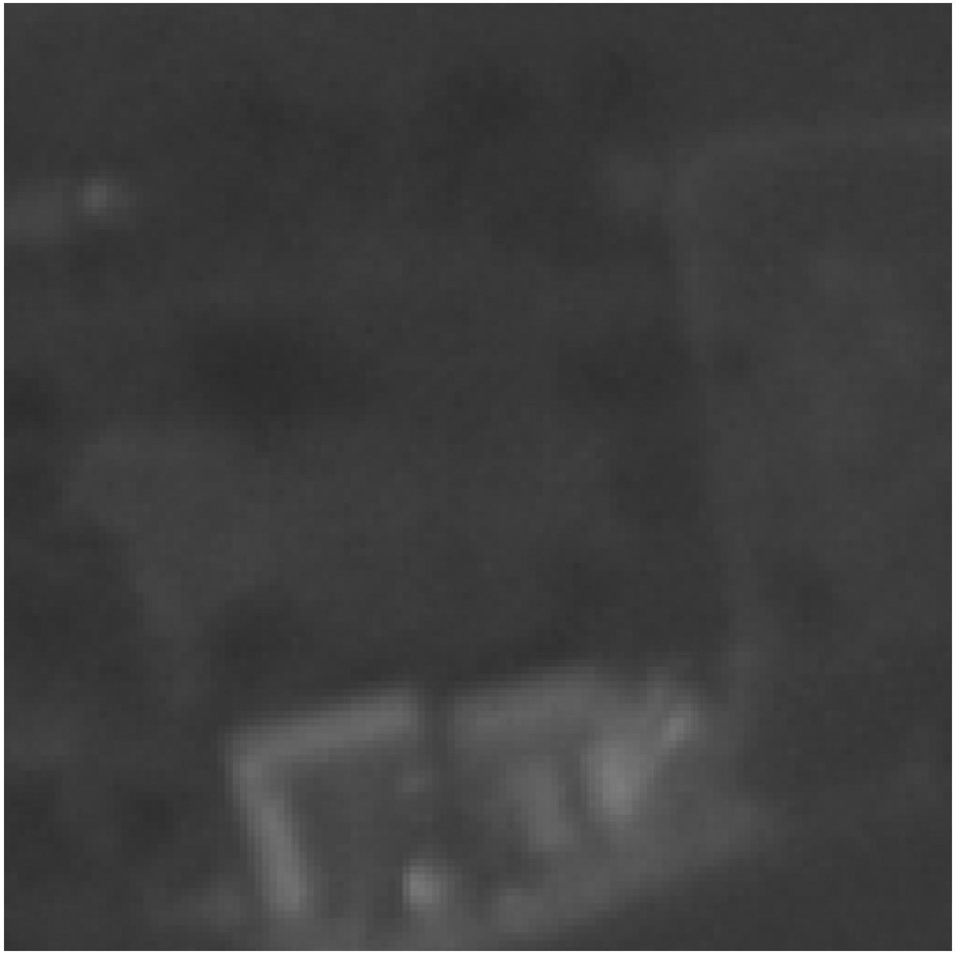


4m Deimos-2 MS green band

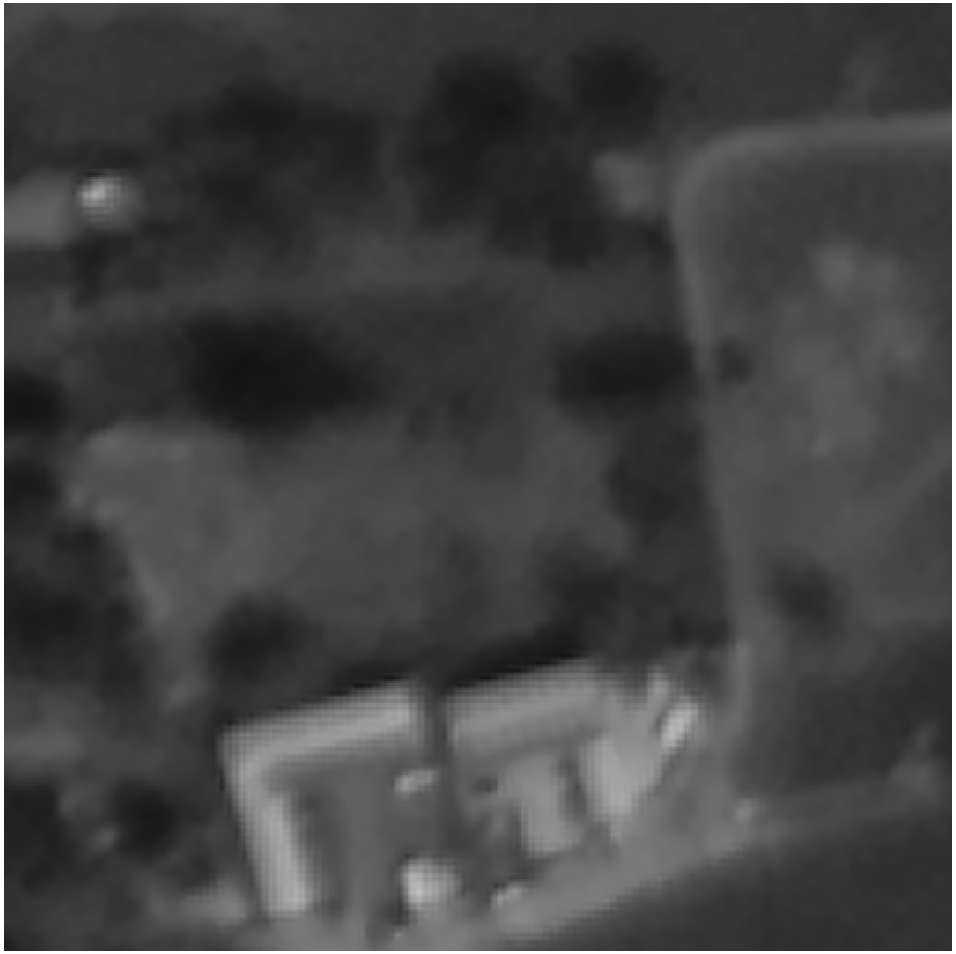
1m SRR from MAGiGAN

1m Deimos-2 PAN band

Results: Carbonite-2 Surrey site



1m Carbonite-2 green band images



Carbonite-2 SRR results

Conclusions

- Demonstrated the MAGiGAN SRR system based on the GPT multi-angle SRR system and deep learning algorithms provides a resolution enhancement factor of 4x.
- The MAGiGAN system not only retrieves subpixel information from multi-angle distorted features, but also uses the GAN network to retrieve high-frequency texture details.
- The MAGiGAN system was integrated onto a space-qualified NVIDIA® Jetson TX-2 GPU board to speed-up processing. Achieved ≈20x cf 16-core linux for GAN (details not shown here).
- Experimental results shown using a time sequence of UrtheCast Corp. Deimos-2 and a single SSTL Carbonite-2 video point-and-stare.

Acknowledgements

The research leading to these results has received funding from the UK Space Agency Centre for Earth Observation Instrumentation (UKSA-CEOI-10 2017-2018) under SuperRes-EO project agreement n° RP10G0435A05.