Temasek Defence Systems Institute

Deblurring of Optically Aberrated Satellite Imagery with Deep Learning

Author: ME5 Siew Jun Jie, Singapore Armed Forces
Thesis Advisors: Dist. Prof Brij N. Agrawal, Naval Postgraduate School
Dr. Jae Jun Kim, Naval Postgraduate School

Introduction

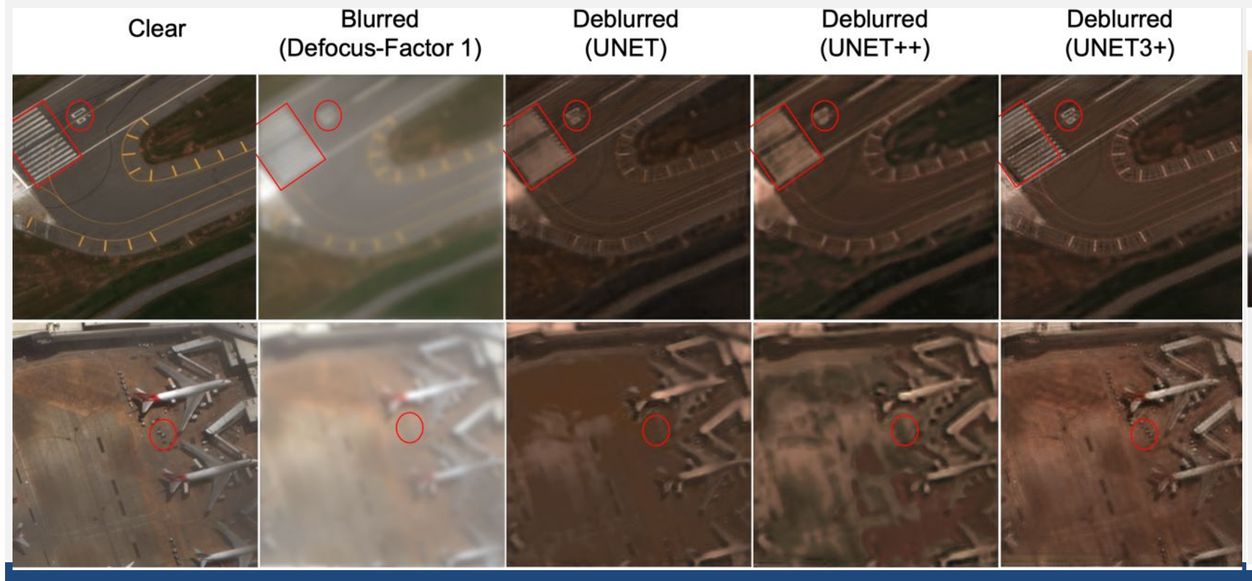
Satellite imaging performance can degrade over time due to optical aberrations caused by optics imperfection and operations in the space environment. To maximize the satellite's imaging output over its useful lifespan, deep learning presents a cost-effective and efficient alternative to traditional adaptive optics and blind deconvolution respectively for deblurring of satellite images.

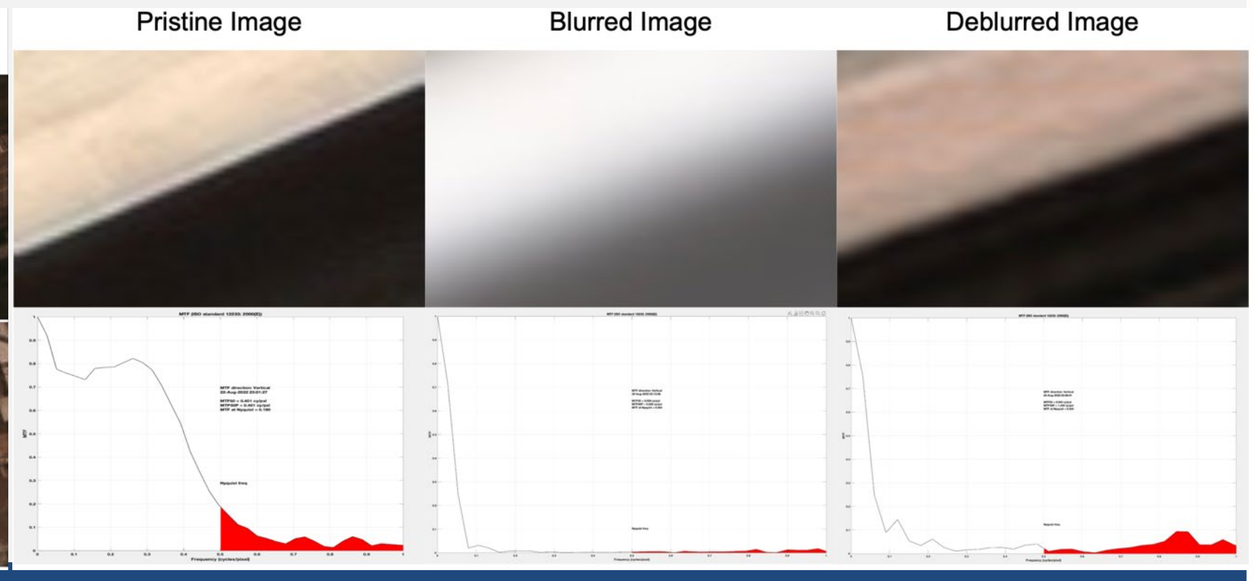
Research Approach

- ❑ Simulate image blurring on World View 3 satellite images with Zernike polynomials.
- ❑ Perform image deblurring with trained convolutional neural networks (UNET, UNET++ and UNET3+) using supervised machine learning and deep learning regression approaches.
- ❑ Compare image deblurring performances quantitatively (mean square error [MSE], peak signal to noise ratio [PSNR] and structural similarity index [SSIM]) and qualitatively (visual).

Key Results

- ❑ Demonstrated that UNET can be used for deblurring optically aberrated satellite imagery.
- ❑ Demonstrated that Deep-UNET3+, which combines UNET3+ and deep UNET convolutional autoencoder, achieved the best deblurring performance.
- ❑ Conventional image quality metrics (MSE, PSNR, SSIM) have limitations, the slanted edge modulation transfer function (MTF) approach may offer a more accurate alternative.





Benefits of Research

UNET can be used to sustain existing capabilities that have degraded over time, and technically deblur/enhance images affected by atmospheric turbulence.

Future Work

UNET can be applied to operational datasets as well as on infrared and radar images. Deblurring performance can be enhanced by combining UNET with generative adversarial networks (GAN).

NUS National University of Singapore