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4th INTERNATIONAL CONFERENCE ON INNOVATIVE COMPUTING
& COMMUNICATION (ICICC-2021)

20-21 February 2021.

Cloud Image Prior: Single Image Cloud Removal

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1. INDEX:

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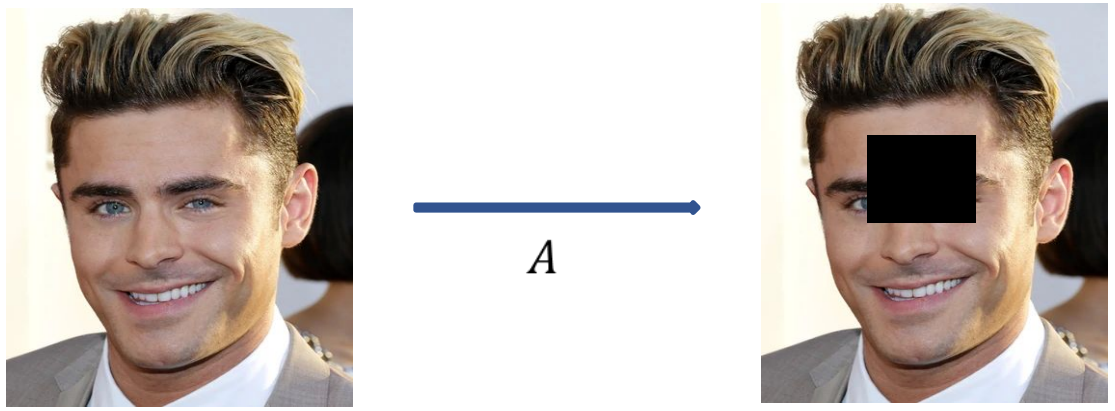
2. ABSTRACT:

- Cloud removal from satellite images is addressed as an inverse problem
- Cloudy regions are treated as missing/corrupted pixels and inpainted in an unsupervised setting
- Eliminate the task of gathering huge datasets to learn the mapping between cloudy and cloudy-free images
- Structure of a convolutional neural network is a good prior and is sufficient to solve an inpainting problem using Deep Image Prior algorithm [1]
- Effectiveness of the technique is demonstrated on Sentinel-2 satellite imagery

3. INTRODUCTION:

What is an Inverse problem?

$$y = A \cdot X$$



Problem : Given y, A find X

Uses:

- Denoising
- Inpainting
- Super resolution
- Deblurring

Often, $y = A \cdot X + n$
where n is noise.
Hence solutions to inverse problems are ill-posed and non-unique

3. INTRODUCTION

- Convolutional Neural Networks (Conv. Nets) have been used in remote sensing domain:
  - Semantic Segmentation of Crops [2]
  - Detecting Urban footprints [3]
- Often, clouds obstruct/envelope satellite images, hence cloud removal as a pre-processing step is imperative for other remote sensing tasks.

4. LITERATURE REVIEW :

Cloud-Gan: Cloud Removal for Sentinel-2 Imagery Using a Cyclic Consistent Generative Adversarial Networks

- Uses Generative Adversarial Networks to learn the mapping between cloudy and cloud free images
- Has an additional cycle consistency loss to constrain the generator
- Requires gathering of data to learn the mapping

Thick Clouds Removal From Multitemporal ZY-3 Satellite Images Using Deep Learning

- Uses multisource data (content, spectral and texture) to build a unified framework
- Hence uses three different Conv. Nets.
- Requires gathering of data to learn the mapping

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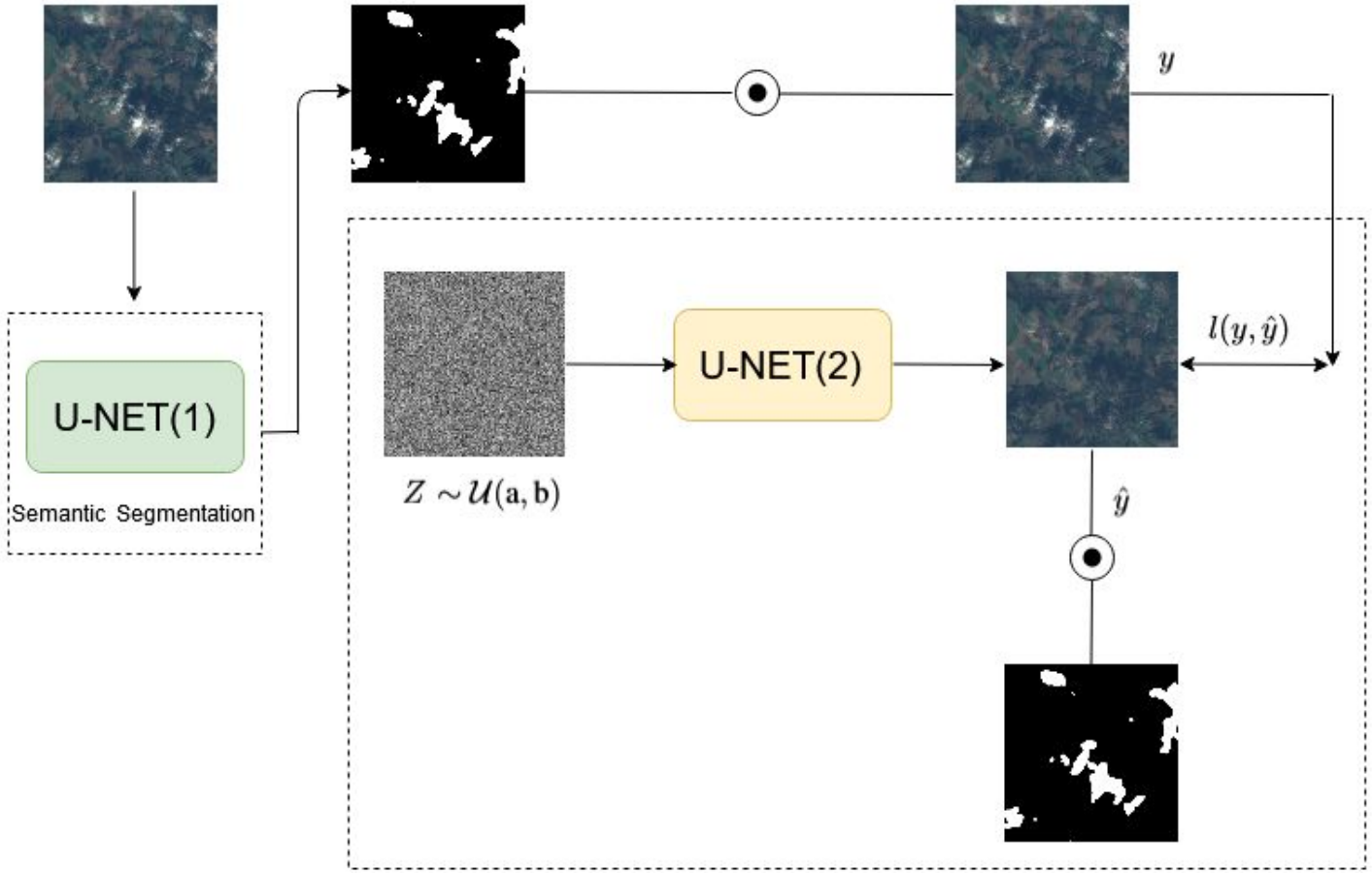
5. PROPOSED METHODOLOGY :



Cloud Removal is done in two stages:

1. Cloud Segmentation (detection)
2. Cloud Removal

Hence, we have two different Conv. Nets (U-Nets).

5. PROPOSED METHODOLOGY :

How to model cloud removal as an inverse problem?

y

A

X

Given *y* and *A*, find cloud-free image *X*

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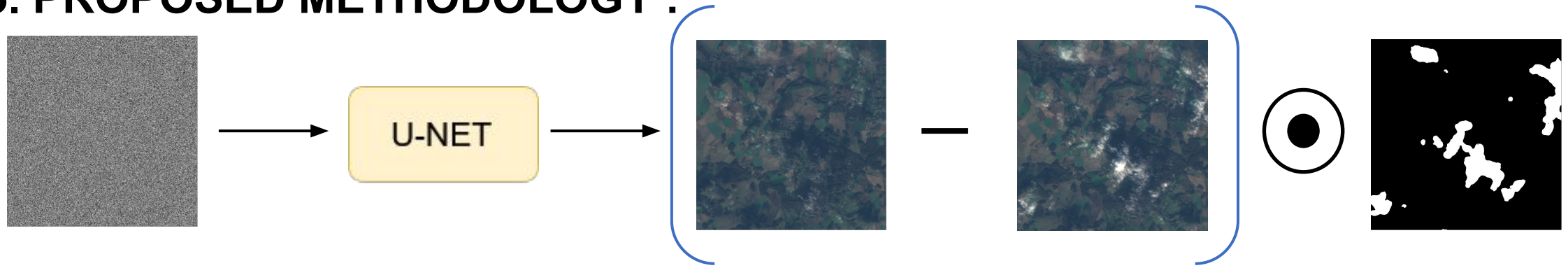
5. PROPOSED METHODOLOGY :



Z $UNet(Z)$ $\hat{y}$ A

Algorithm 2: Cloud Image Prior for a single image

Require: $\hat{y}$ - Corrupted Image (Cloudy Image)
Require: m - Mask (from Cloud Segmentation)
Require: α - Step Size

1: Initialize z with meshgrid where $z \in R^{H \times W \times 2}$
2: Obtain segmentation mask m from trained Cloud Segmentation model
3: Solve the optimization problem by finding the parameters of the network.
$\theta_t = \theta_{t-1} - \alpha \cdot \nabla_\theta J(\theta_{t-1})$ where J is the cost function defined as
$J(f_\theta(z), \hat{y}) = \left\| (f_\theta(z) - \hat{y}) \odot m \right\|^2$
4: Find the solution to the desired inpainting problem after the model has converged.
$y^* = f_{\theta^*}(z)$

7. RESULTS & DISCUSSION:

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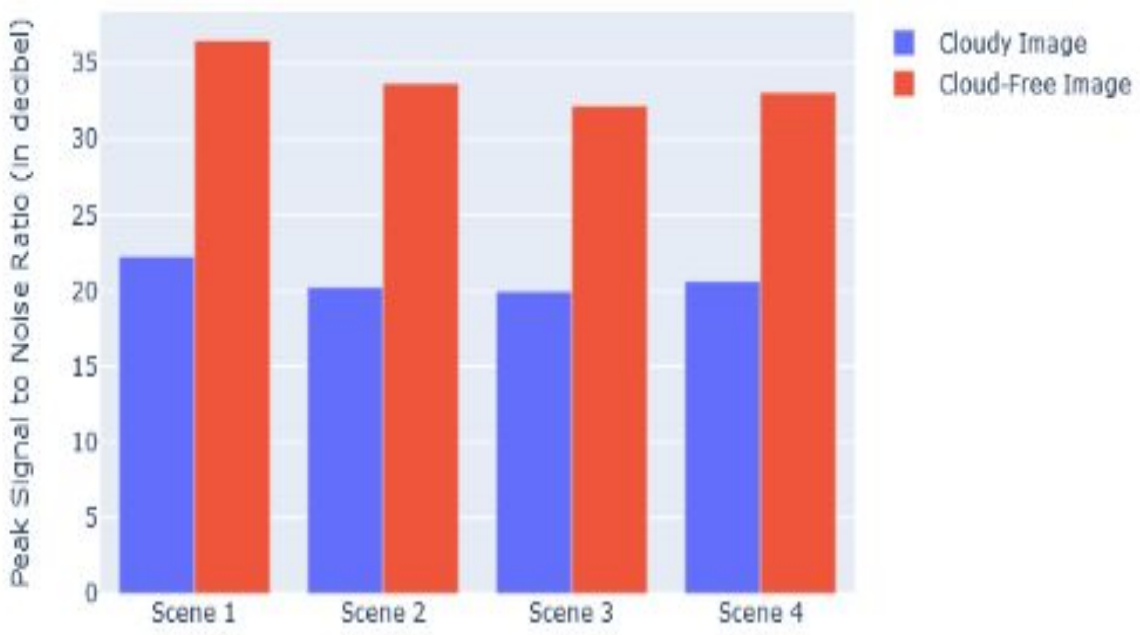
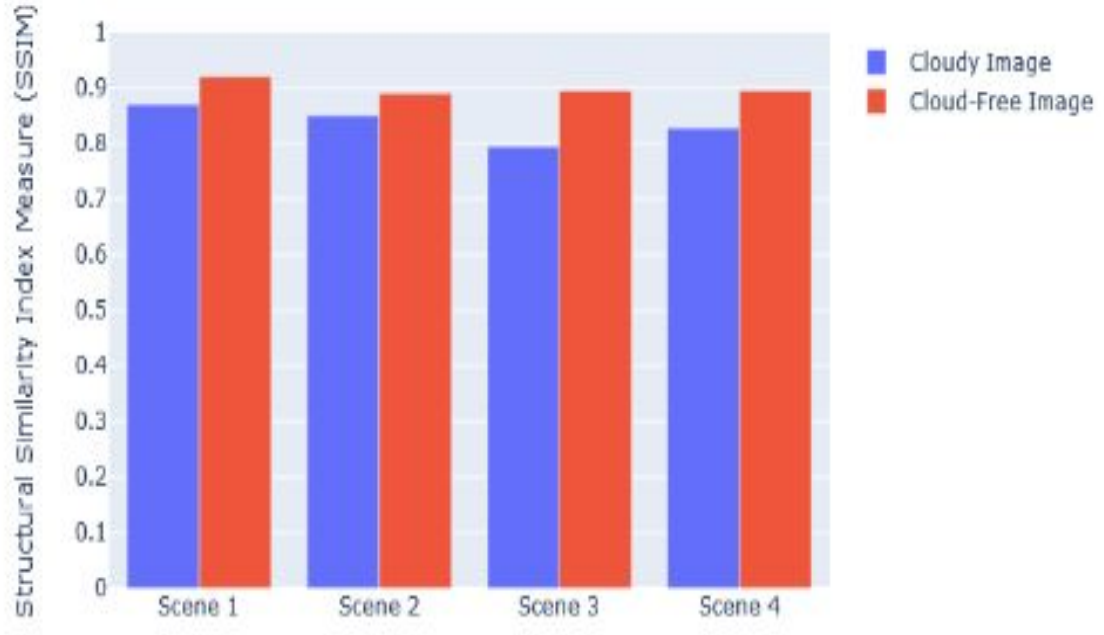
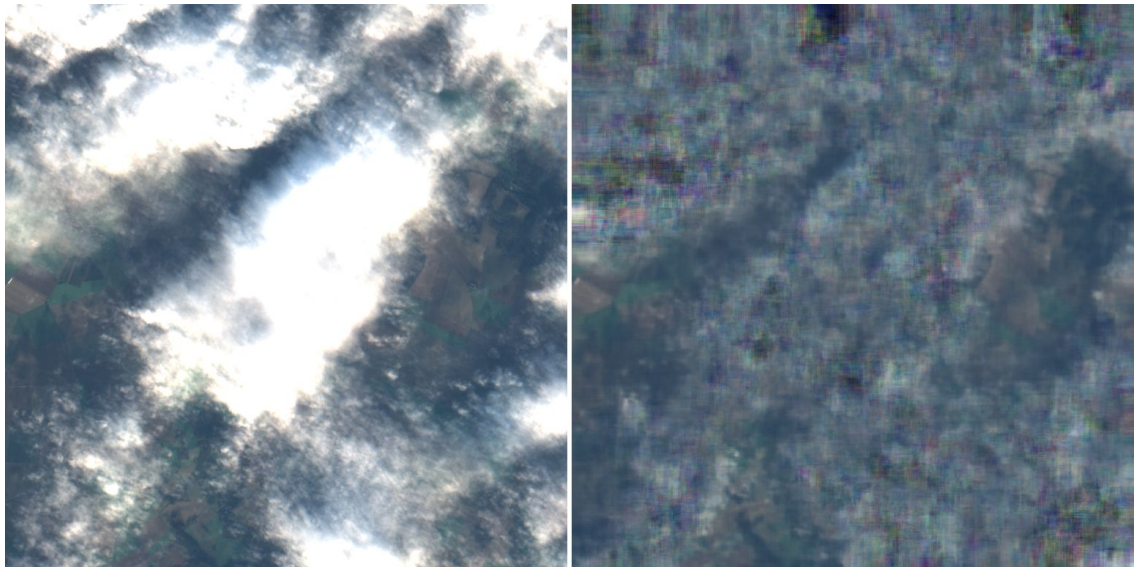




Quantitative results such as PSNR and SSIM on four different scenes

7. RESULTS & DISCUSSION:



- Grainy output is produced when the image is significantly enveloped with clouds

9. CONCLUSION:

- Cloud removal is done with a single image
- Structure of the network contains significant amount of information and is sufficient to learn the prior
- Good baseline for superior/exotic supervised techniques to compete with

10. FUTURE WORK

- Removal of cloud shadows
- More granularity w.r.t thin and thick clouds
- Utilize other bands from Sentinel-2

10. REFERENCES :

1. D. Ulyanov, A Vedaldi and V.S. Lempitsky, Deep Image Prior, International Journal of Computer Vision, vol. 128, pp. 1867–1888, 2020

2. P. Singh and N. Komodakis, Cloud-Gan: Cloud Removal for Sentinel-2 Imagery Using a Cyclic Consistent Generative Adversarial Networks, in IEEE International Geoscience and Remote Sensing Symposium, pp. 1772-1775, 2018

3. Y. Chen, L. Tang, X. Yang, R. Fan, M. Bilal and Q. Li, Thick Clouds Removal From Multi-temporal ZY-3 Satellite Images Using Deep Learning, in IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol. 13, pp. 143-153, 2019

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