Filmy Cloud Removal on Satellite Imagery with Multispectral Conditional Generative Adversarial Nets

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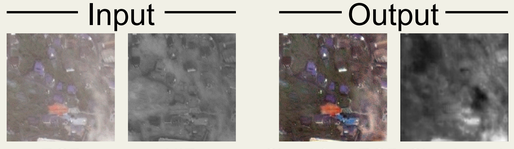
IEEE 2017 Conference on Computer Vision and Pattern Recognition
CVPR July 21-26 2017 HONOLULU

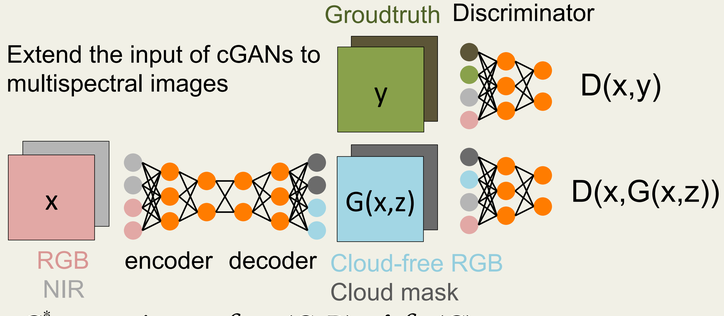
Introduction



Goal:
- Remove clouds and generate visible light images from the multispectral images

Methodology:
- Generate the training data by synthesizing cloud obscured images
- Improve the bias of the training dataset using t-SNE

McGANs (Multispectral cGANs)



$$G^* = \arg\min_G \max_D \mathcal{L}_{cGAN}(G,D) + \lambda \mathcal{L}_{L1}(G)$$

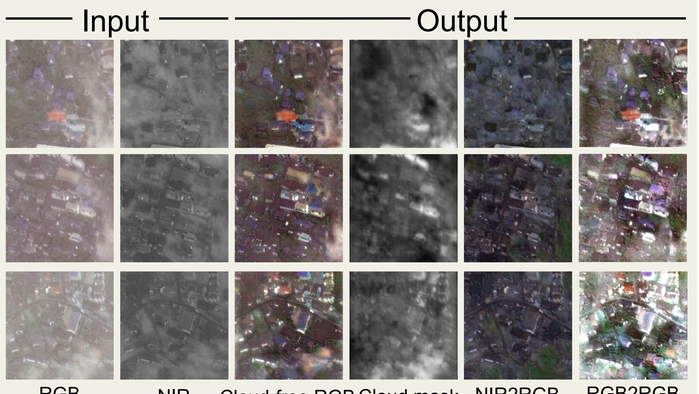
$$\mathcal{L}_{cGAN}(G,D) = E_{x,y\sim p_{data}(x,y)}[\log D(x,y)] + E_{x\sim p_{data}(x)}[\log(1 - D(x,G(x,z)))]$$

Encoder	Decoder	Discriminator
CR(64, 3, 1)	CBRD(512, 4, 2)	CBR(64, 4, 2)
CBR(128, 4, 2)	CBRD(512, 4, 2)	CBR(128, 4, 2)
CBR(256, 4, 2)	CBRD(512, 4, 2)	CBR(256, 4, 2)
CBR(512, 4, 2)	CBR(512, 4, 2)	CBR(512, 4, 2)
CBR(512, 4, 2)	CBR(256, 4, 2)	C(1, 3, 1)
CBR(512, 4, 2)	CBR(128, 4, 2)	
CBR(512, 4, 2)	CBR(64, 4, 2)	
CBR(512, 4, 2)	C(4, 3, 1)	

C: Convolution B: Batch Normalization
R: ReLU D: Dropout

$$\mathcal{L}_{L1}(G) = \frac{1}{4HW}\sum_{c=1}^{4}\sum_{v=1}^{H}\sum_{u=1}^{W}\lambda_c \left| I_T^{(u,v,c)} - \phi(I_M)^{(u,v,c)} \right|_1$$

Results



NIR2RGB: Color information is partially missing
RGB2RGB: The clouds are partially removed, there are crucial errors in some results
McGANs: The overall filmy cloud is removed

Dataset

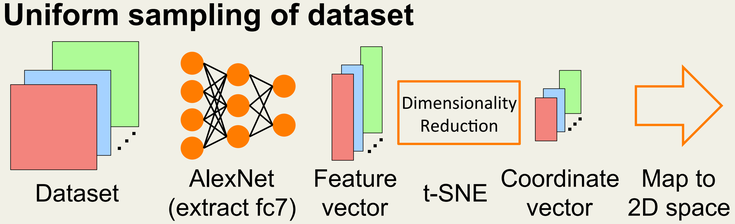
Cloud synthesis

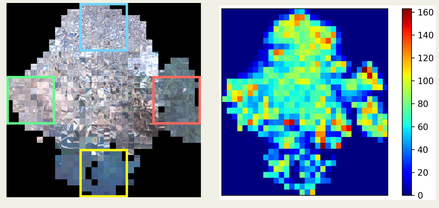
Why synthesize? It is difficult to obtain cloud obscured images and cloud-free images of a location at the same time.

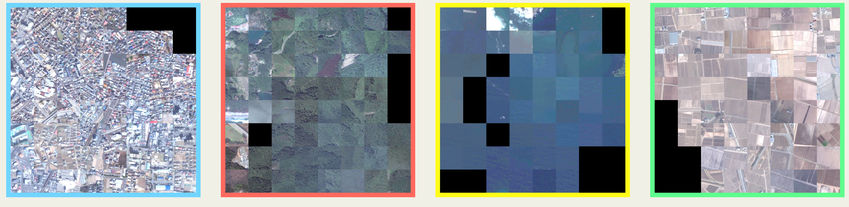
Perlin noise
Pixel value:
$(255,255,255,\alpha) \quad (\alpha : 0 \sim 1)$

$$I_{synth}(R,G,B) = (1-\alpha) I_{sat}(R,G,B) + \alpha I_{cloud}(R,G,B)$$

Uniform sampling of dataset

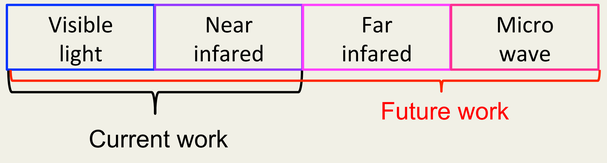






- The images are well clustered according to their categories
- Images are sampled uniformly grid by grid to avoid the overfitting

Future work



McGANs: Extend to image data captured by longer wavelengths

Cloud synthesis: Statistical analysis of cloud obscured images to improve the reality of synthesized images