

Using Generative Adversarial Networks (GAN) for multi-channel colorization of satellite images

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Image colorization was achieved using a generalizable GAN framework

- Satellite image colorization can enable additional content value:
 - Increased performance in object detection algorithms
 - Data augmentation of small datasets
 - Data usability in bandwidth-limited scenarios
- SpaceNet satellite images were used to train a Generative Adversarial Network (GAN) for multi-channel colorization.
- Generated images have credible color with average PSNR values between 30-40

Previous work on colorization tasks

Deep Colorization¹



Colorful image colorization²

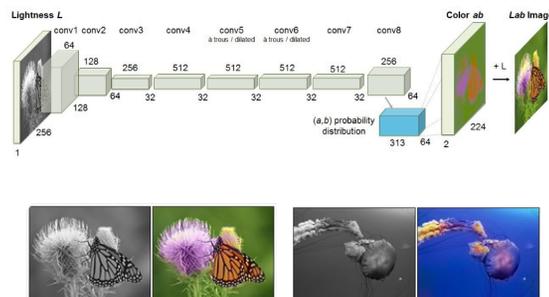


Image-to-image Translation with Conditional Adversarial Networks³



- DNN + clustering for global info
- Mapping into continuous color values in YUV space
- Framed as regression

- CNN
- Mapping into quantized color values in CIE Lab color space
- Framed as a classification

- Conditional GAN
- Set as translation task
- L1 regularization

¹Z. Chen *et al.*, [arXiv:1605.00075](https://arxiv.org/abs/1605.00075) [cs.CV] (2016).

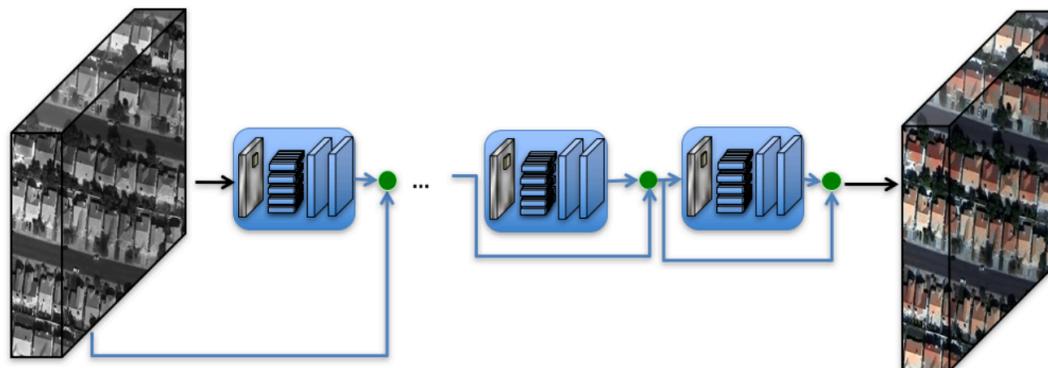
²R. Zhang *et al.*, [arXiv:1603.08511](https://arxiv.org/abs/1603.08511) [cs.CV] (2016).

³P. Isola *et al.*, [arXiv:1611.07004](https://arxiv.org/abs/1611.07004) [cs.CV] (2016).

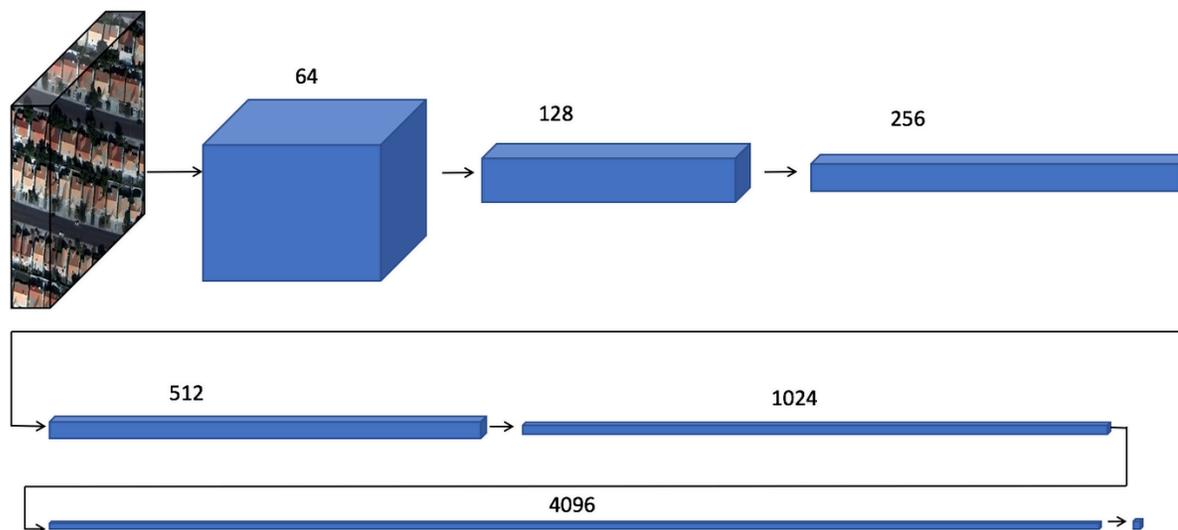
GAN infrastructure for multi-channel colorization

FRAMEWORK

Generator Network



Discriminator Network

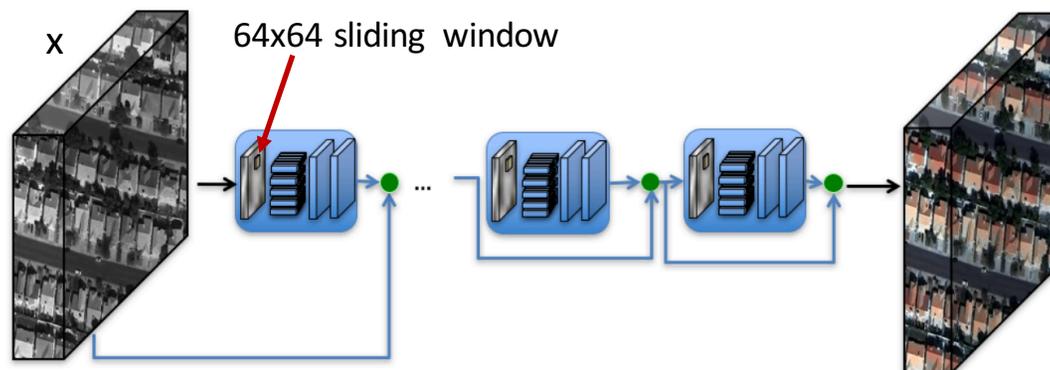


GAN infrastructure for multi-channel colorization

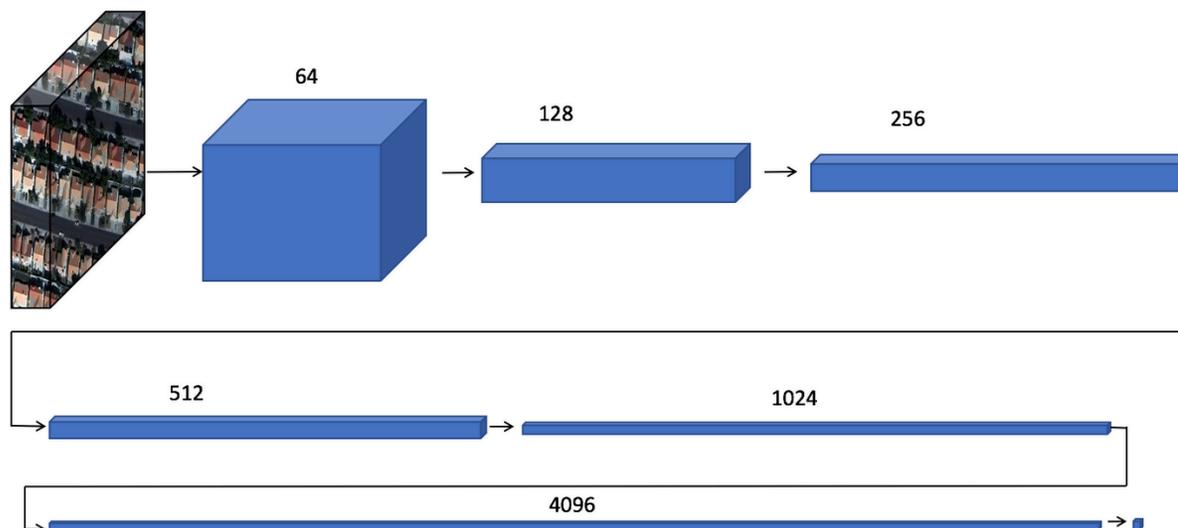
FRAMEWORK

Generator Network

$G(x) \rightarrow$ generate fake image



Discriminator Network

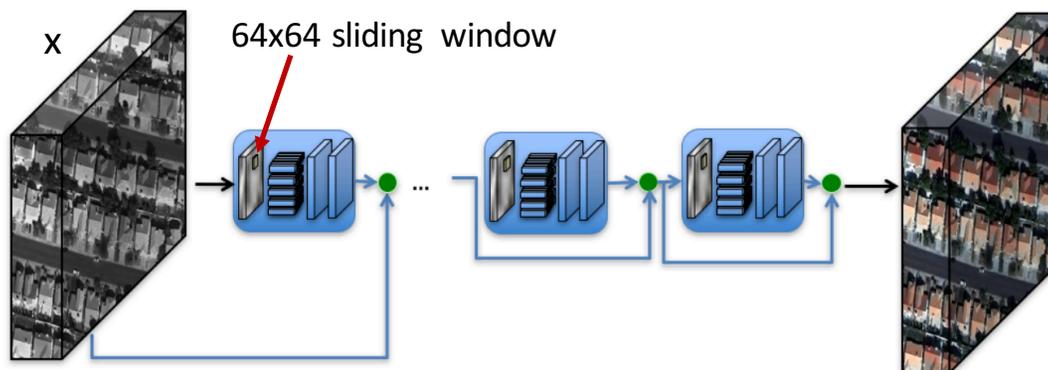


GAN infrastructure for multi-channel colorization

FRAMEWORK

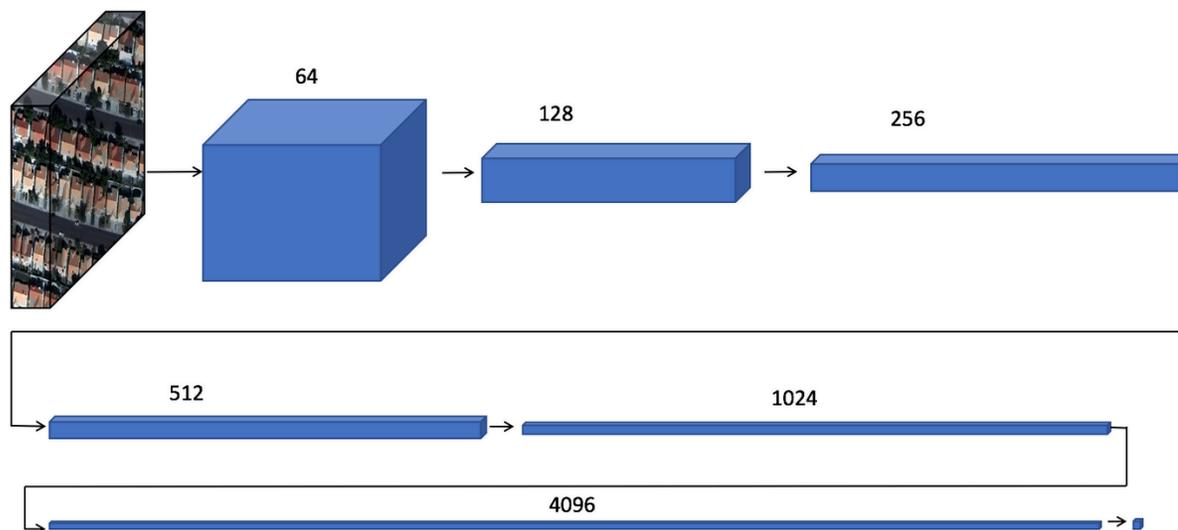
Generator Network

$G(x) \rightarrow$ generate fake image



Discriminator Network

$D(y)$

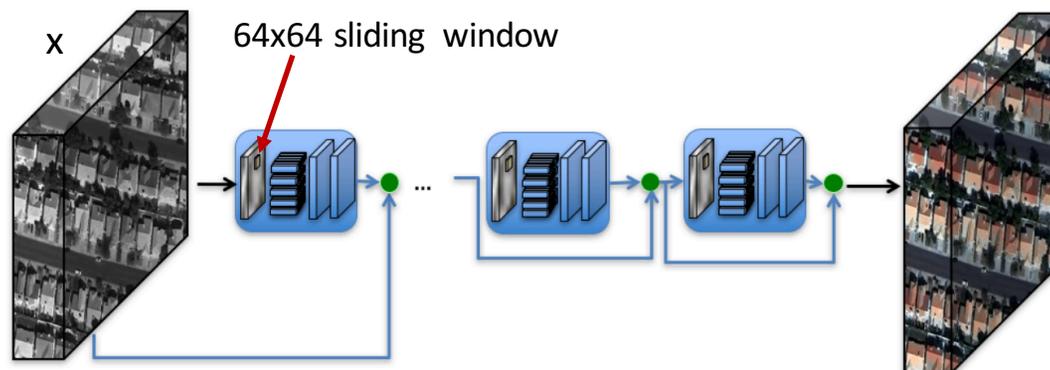


GAN infrastructure for multi-channel colorization

FRAMEWORK

Generator Network

$G(x) \rightarrow$ generate fake image

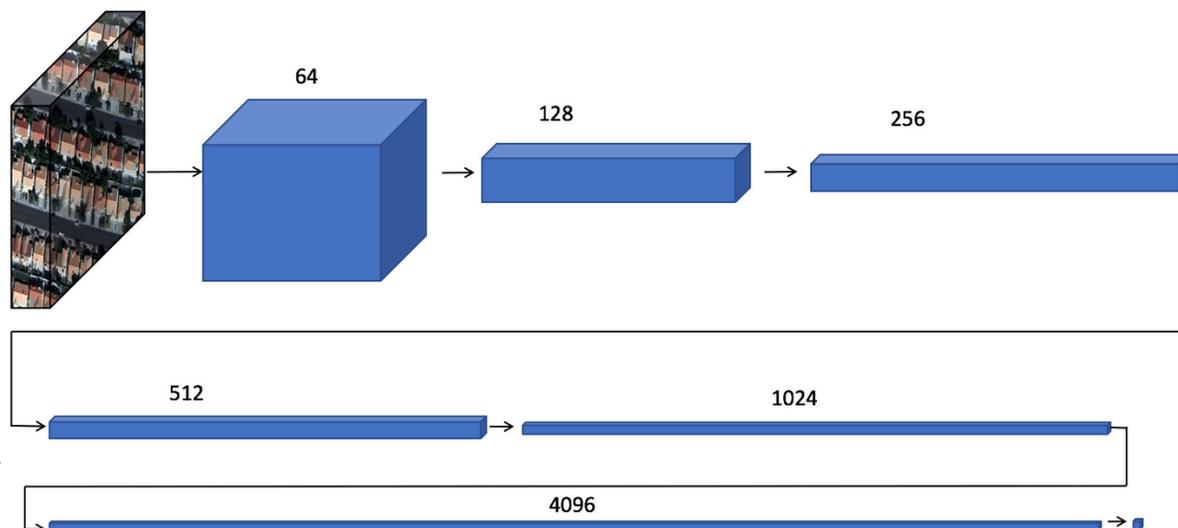


$\{ \log(1-D(G(x))) \}_{min}$

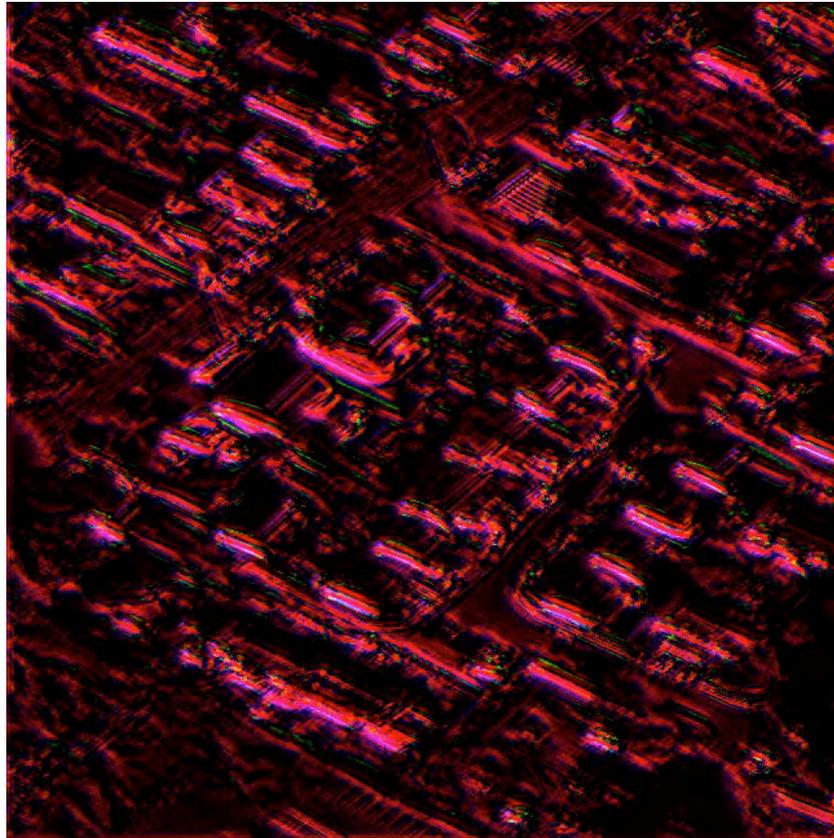
Discriminator Network

$D(y)$

$\{ \log(D(y))+\log(1-D(G(x))) \}_{max}$



The $G(x)$ iterates through colorization based on $D(G(x))$ results



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GAN model generates realistic colorization



Generated RGB image

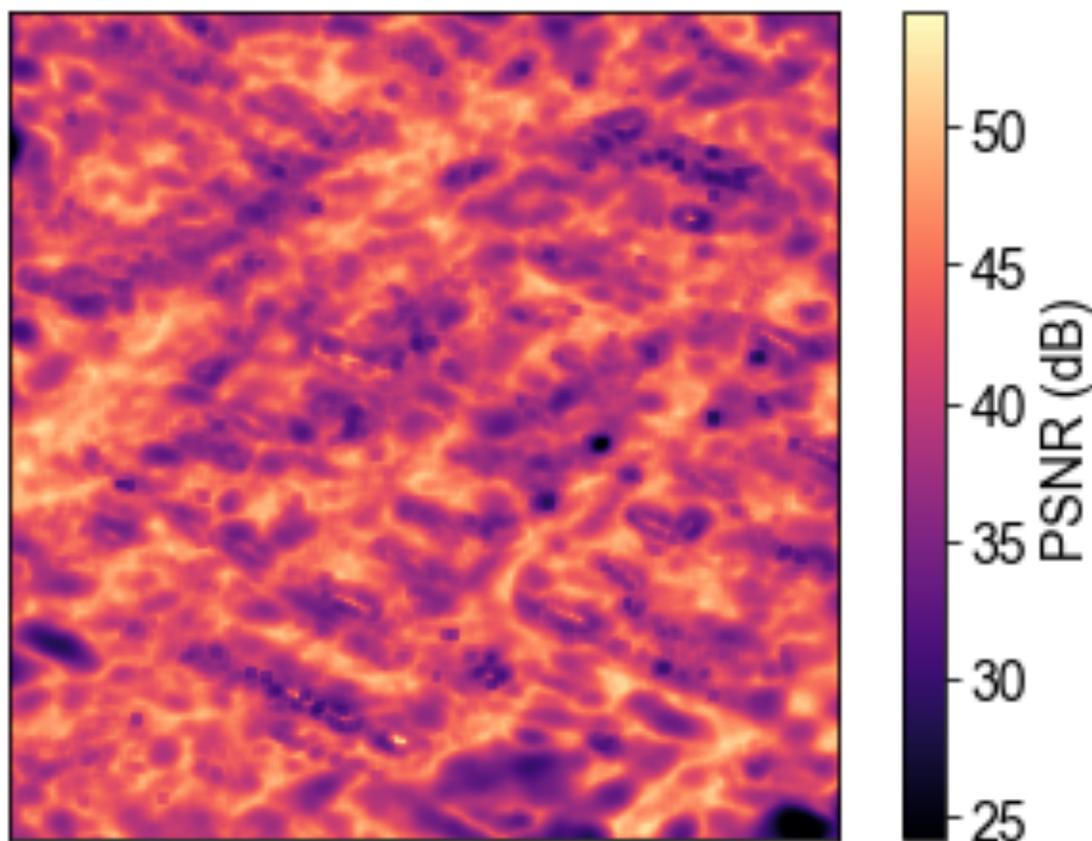
GAN model generates realistic colorization

True RGB image



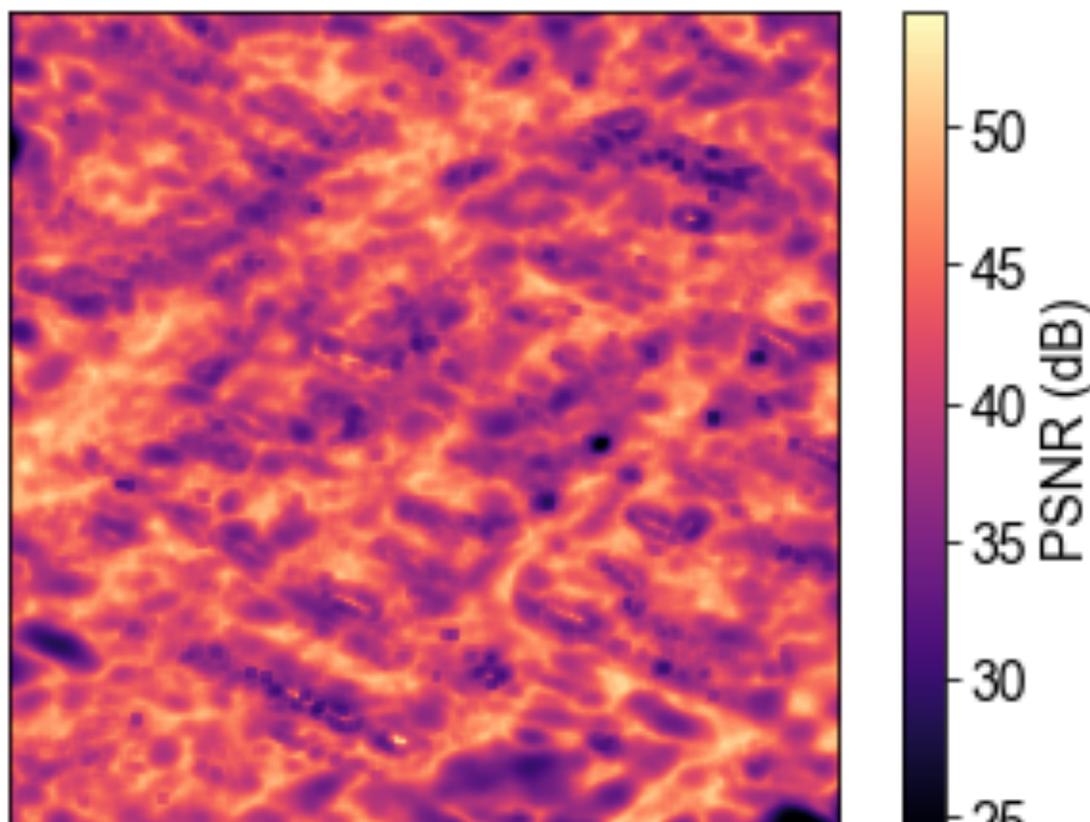
Generated RGB image

GAN model generates realistic colorization



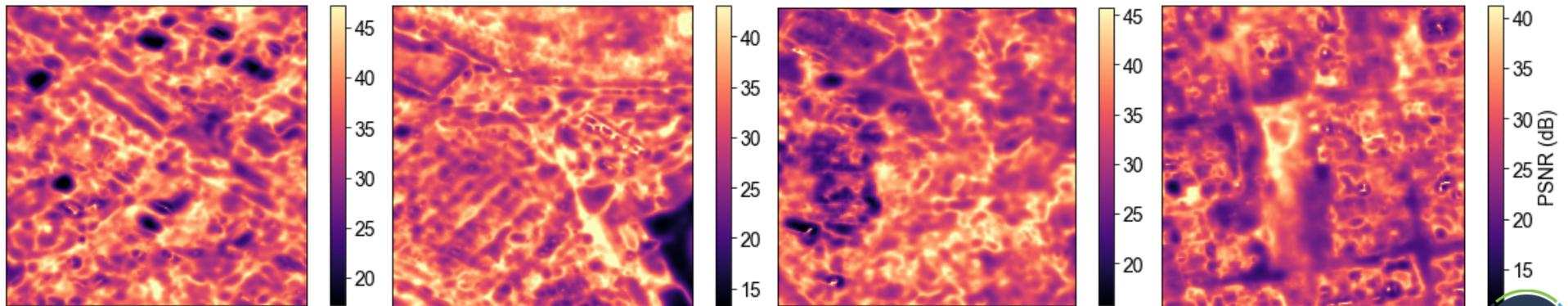
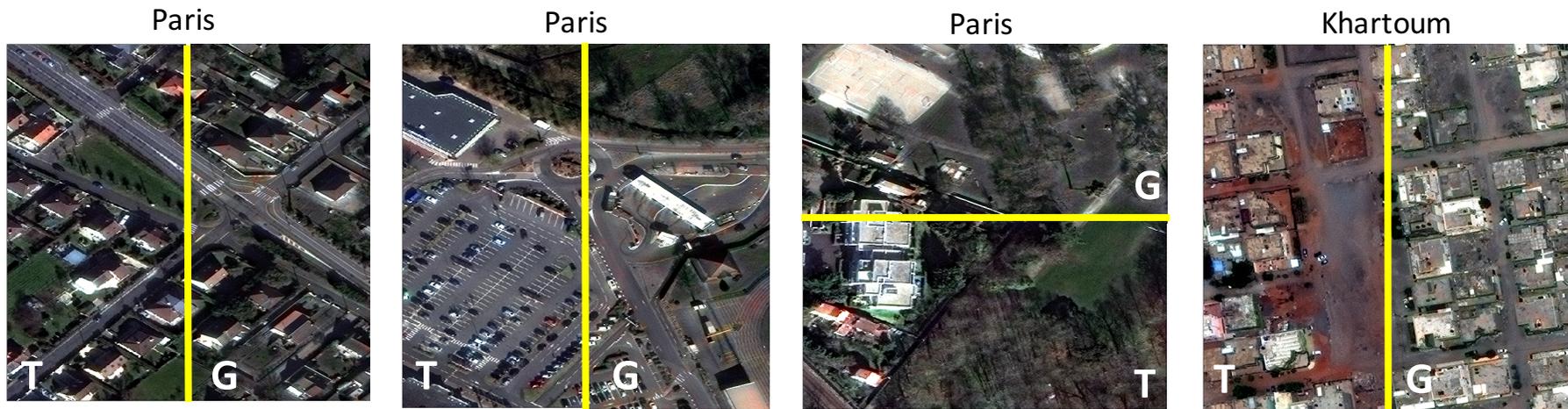
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GAN model generates realistic colorization

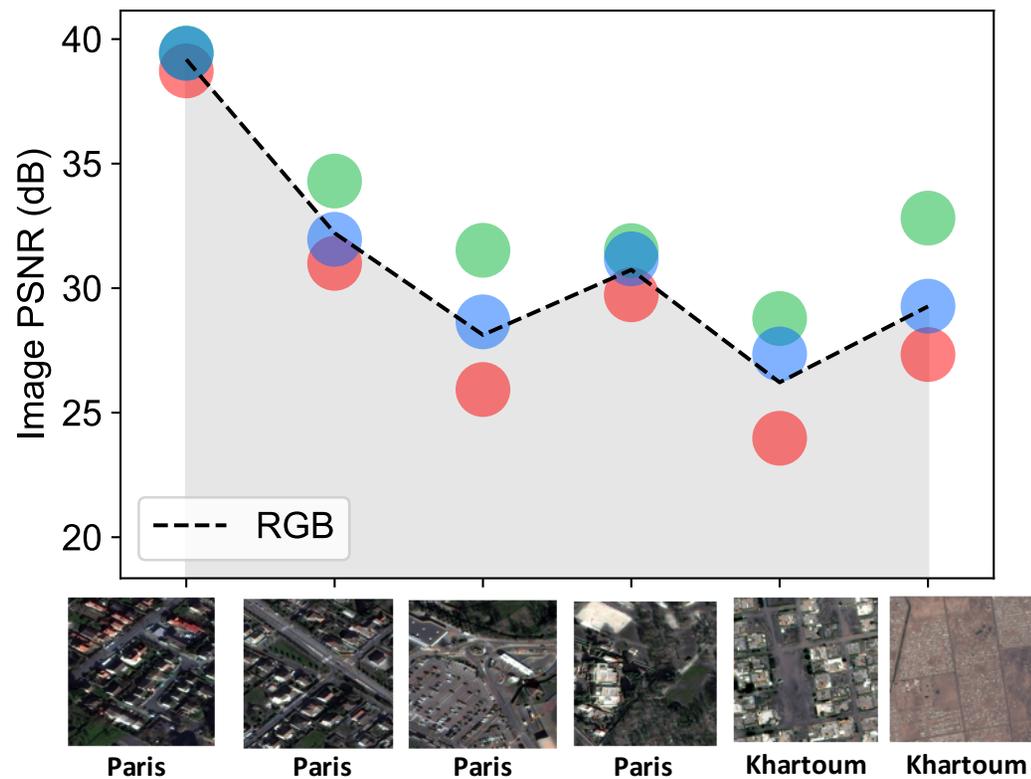


Peak signal-to-noise ratio, over all channels, averages 40

Model does reasonably well with out of sample images



PSNR variations per channel



GAN model has similar performance for 8 channel case

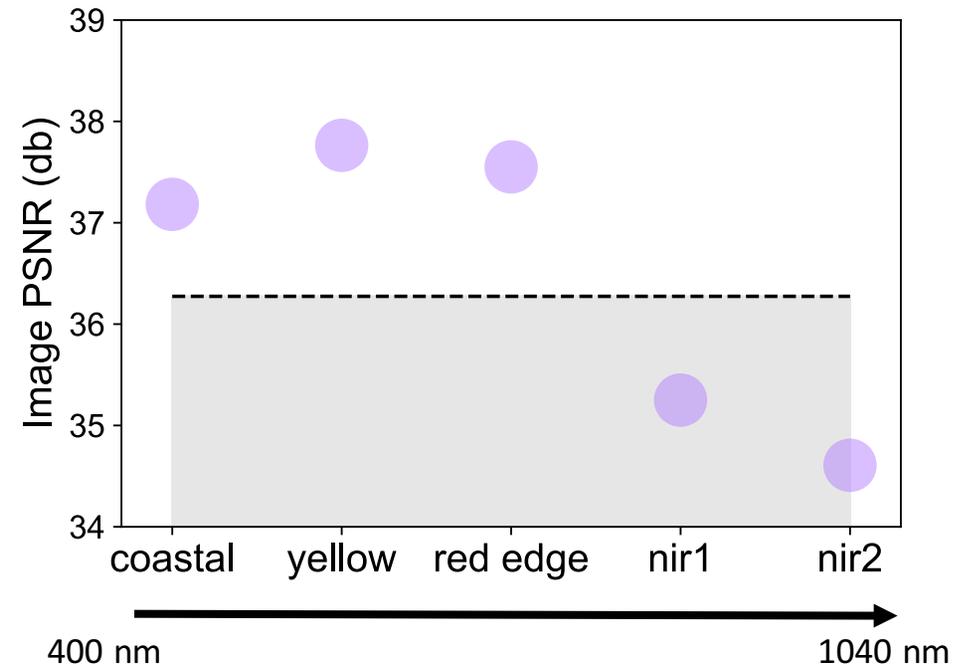
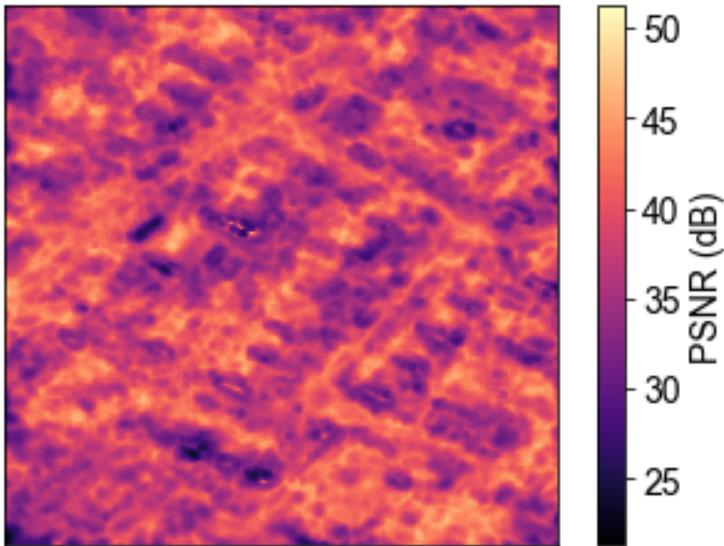


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