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Super-Resolution Generative Adversarial Network for Panchromatic Satellite Images of TeLEOS-1

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Abstract

TeLEOS-1 is Singapore's first commercial satellite, which offers 1m resolution panchromatic images. As though the images have been successfully used in various areas, the resolution is still quite low. In order to obtain high-resolution images, we use 0.3m WorldView images to self-supervised train a super-resolution generative adversarial network and then utilize the best saved model to produce high-resolution TeLEOS images. Experimental results show that SRGAN can improve a TeLEOS image' resolution.

1. Introduction

TeLEOS-1 as a first commercial imaging satellite of Singapore was successfully launched on 16 December 2015, operating at an altitude of 500 km [1]. It offers 1m ground resolution panchromatic imagery at nadir, and a swath width of about 12 km, with a revisit time of 12 to 16 hours. Such imagery has been successfully used in the areas of maritime security and disaster management such as shipping routes, pollution, earthquake.

Even though its wide application in various areas, TeLEOS-1's spatial resolution is still quite limited, because of its large field of view, which results in the lack of details of ground objects. To solve this problem, super resolution (SR) of TeLEOS-1 imagery is important. Image super-resolution focuses on reconstruction the corresponding high-resolution (HR) image from the original low-resolution (LR) image, renders the HR image with upgradation of the LR one.

Traditional methods for SR use nearest-neighbour, bi-linear interpolation to resize an image, with a generic high pass filter sharpening the image. However, those methods still result in a blurred image and tend to create artifacts. To solve these problems, in recent years, deep learning-based methods have been intensely explored and achieved great success in computer vision areas. Dong et al. presented a SR algorithm based on convolutional neural network [2]. Later, a fast super-resolution conventional neural network as an improved model was proposed by the same group [3]. Ledig et al. proposed a super-resolution generative adversarial network (SRGAN) [4]. Instead of mean square error loss function, SRGAN uses a new perceptual loss function.

In this paper, we utilize SRGAN to improve TeLEOS-1' spatial resolution. As TeLEOS-1 lacks HR image, we first use WorldView-3 imagery [5], whose resolution is 0.3m, to self-supervised train SRGAN model, then adopt the best saved model to produce HR images of TeLEOS.

2. Method

The self-supervision learning in SRGAN is realised by first downsampling the resolution of an input 0.3m WorldView image to 1m. A GAN generator then upsample the 1m images back to 0.5m SR images. A discriminator network quantifies the losses of the SR image compared to the original image. A feedback mechanism backpropagate these losses to improve the discriminator and the generator. SRGAN model architecture [4] of generator and discriminator network is shown in Figure 1, and the workflow of SRGAN is shown in Figure 2. The generator of SRGAN was based on Residual blocks. Specifically, every block contains two convolutional layers followed by batch-normalization layer and ParametricReLU layer. For discriminator network, LeakyReLU is used as activation function. Mode's losses include three parts: Pixel loss, D loss and G loss. Pixel loss is calculated by the mean square error between the pixel value of generated SR image and the original HR image. D loss is discriminator loss, and G loss is generator loss as written in [4].

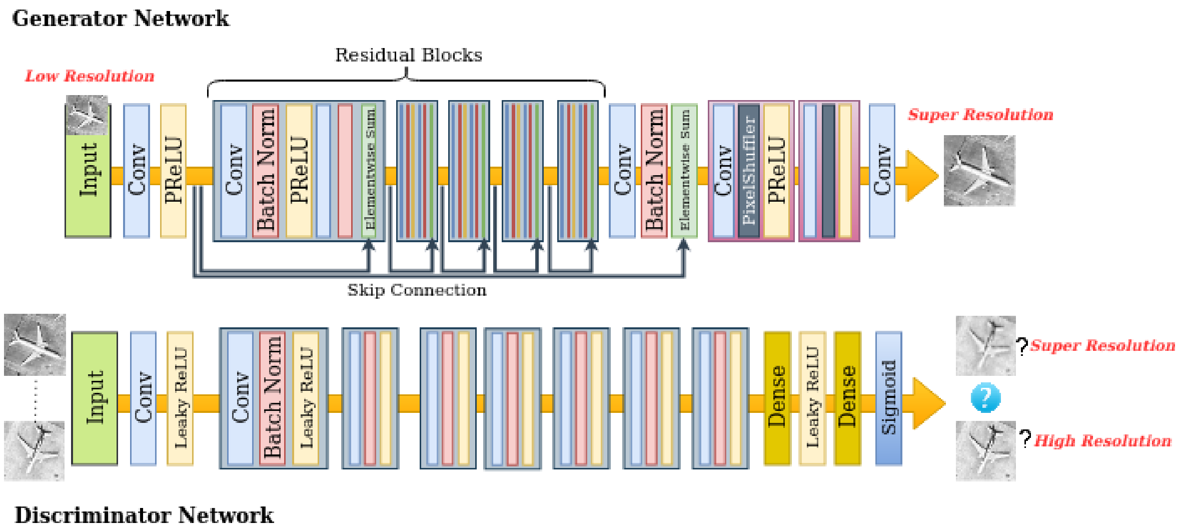

Figure 1. SRGAN model architecture of Generator and Discriminator network.

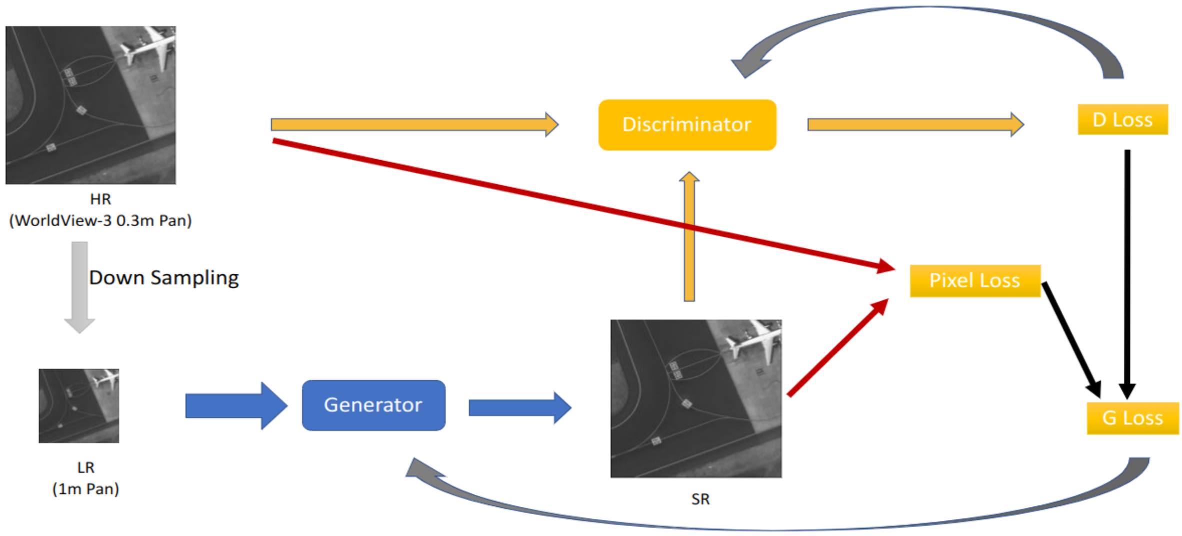

Figure 2. Workflow of the SRGAN model.

3. Experimental Results

Figure 4 shows 6 samples of our experimental results for WorldView images, which include forest, mountain, buildings et al. We can see that SRGAN is able to highly improve the quality of a dowansampling image to a quite high-resolution one. Especially, lines like roof edges, road lines become much shaper and clearer; textures of waves and forests contain more information. Then, after training 100 epochs, we choose the best model to predict a HR image for a TeLEOS image. Figure 5 shows the comparison between original LR TeLEOS images and their corresponding predicted HR images. We can see the saved best SRGAN model can also improve TeLEOS images.

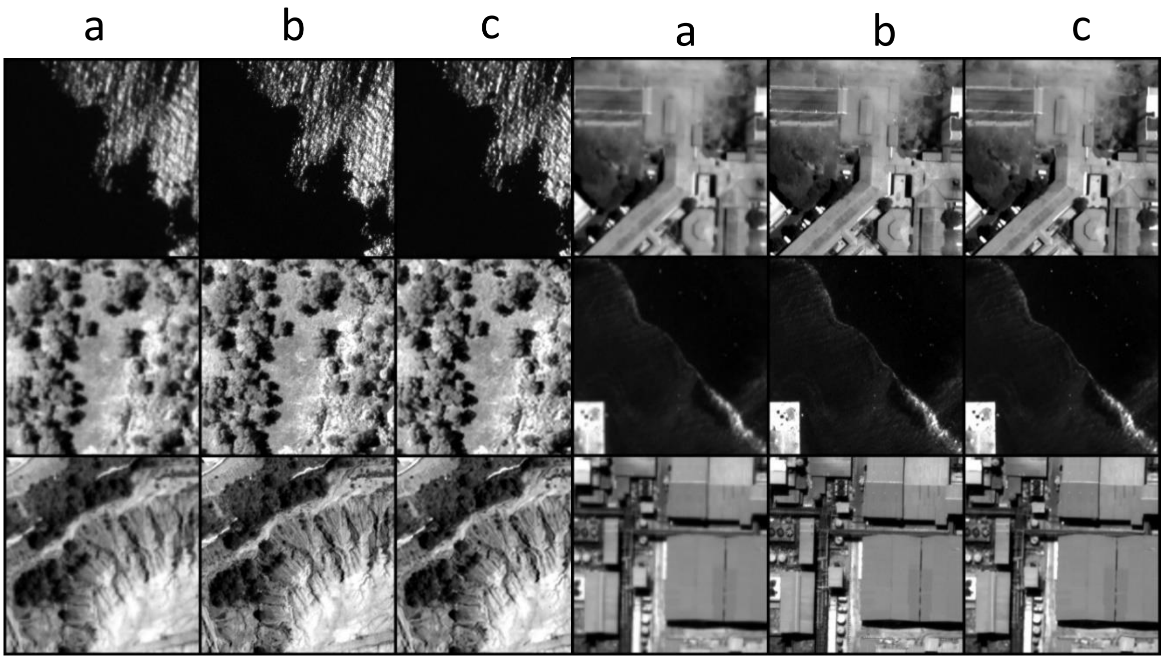

Figure 3. Samples of experimental results for WorldView images. ‘a’ denotes downsampling images; ‘b’ denotes original 0.3m WorldView images which are treated as ground truth; ‘c’ denotes the corresponding predicted HR images.

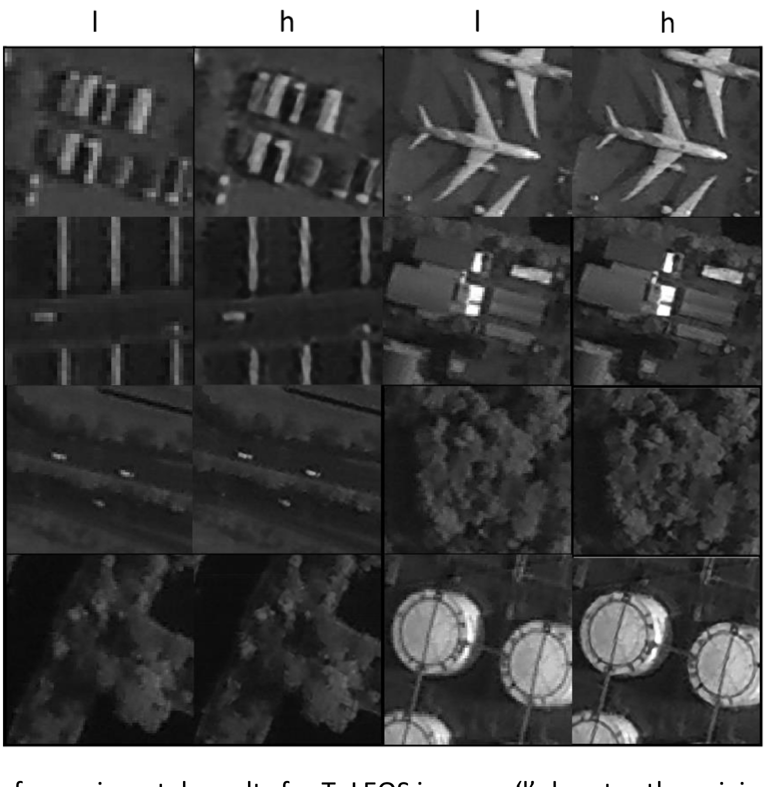

Figure 4. Samples of experimental results for TeLEOS images. ‘l’ denotes the original 1m resolution images. ‘h’ denotes the corresponding produced HR images.

4. Conclusion

In this paper, we mainly explore the super resolution of TeLEOS-1 satellite image. For the training dataset, 0.3m WorldView images are used to self-supervised learn the SRGAN model. Then the saved best model is adopted to predict a HR image for an original LR image of TeLEOS. Experimental results show that SRGAN can be used to improve 1m TeLEOS images to HR ones.

References

[1] TeLEOS-1, EO Portal Directory. https://directory.eoportal.org/web/eoportal/satellite-missions/t/teleos-1 (Accessed Jan 9, 2017)

[2] Dong, C., Loy, C.C., He, K., Tang, X., 2016a. Image super-resolution using deep convolutional networks. IEEE Trans. Pattern Anal. Mach. Intell. 38 (2), 295–307.

[3] Dong, C., Loy, C.C., Tang, X., 2016b. Accelerating the super-resolution convolutional neural network. In: Leibe, B., Matas, J., Sebe, N., Welling, M. (Eds.), Computer Vision – ECCV 2016. Springer International Publishing, Cham, pp. 391–407.

[4] Ledig, C., Theis, L., Huszár, F., Caballero, J., Cunningham, A., Acosta, A., Aitken, A., Tejani, A., Totz, J., Wang, Z., Shi, W., 2017. Photo-realistic single image super-resolution using a generative adversarial network. In: 2017 IEEE Conference on Computer Vision and Pattern Recognition (CVPR). pp. 105–114.

[5] WorldView. https://earth.esa.int/eogateway/missions/worldview-3.