Fusion of Multi-spectral and Hyper-spectral Data for classification.

Advaith C A,
MTech, PRSD.
Guide: Mr Vinay Kumar

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Overview

Introduction

- **Fusion in Remote Sensing** - Improve the spectral resolution without loss in spatial resolution.
- **Conventional techniques for Fusion** include IHS image fusion, Brovey transform image fusion, Principal Component Analysis image fusion, Wavelet image fusion etc.
- **Generative Adversarial Network** is a kind of Neural Network that has two components - a Generator and a Discriminator.
- GAN can be used in RS fusion. GAN has been used for Neural Style transfer in which the style data of one image is transferred to another.
- GAN models opposing relationships, such relationships are present widely in remote sensing.

Image Fusion

1. Combines properties of multiple images to produce outputs that have the best of both (all) worlds.
2. Fused output usually provides more information than any of the images taken one at a time.

Why image fusion?

1. Improved spatial and spectral resolution.
2. Wider temporal coverage.
3. Better performance in tasks such as classification.
4. Good fusion technique has the following characteristics: high computational efficiency, better spatial resolution, reduced color distortion.

Generative Adversarial Networks

- GAN was proposed by Goodfellow et al. **Goodfellow2020**
- *GAN*s are a kind of Neural Networks that consist of two neural networks - one acting as a discriminator, another as a generator.
- The *generator* learns the data distribution, and tries to generate the distribution.
- The *discriminator* tries to predict whether the generated distribution is the data distribution or the model distribution.

Generative Adversarial Networks Contd..

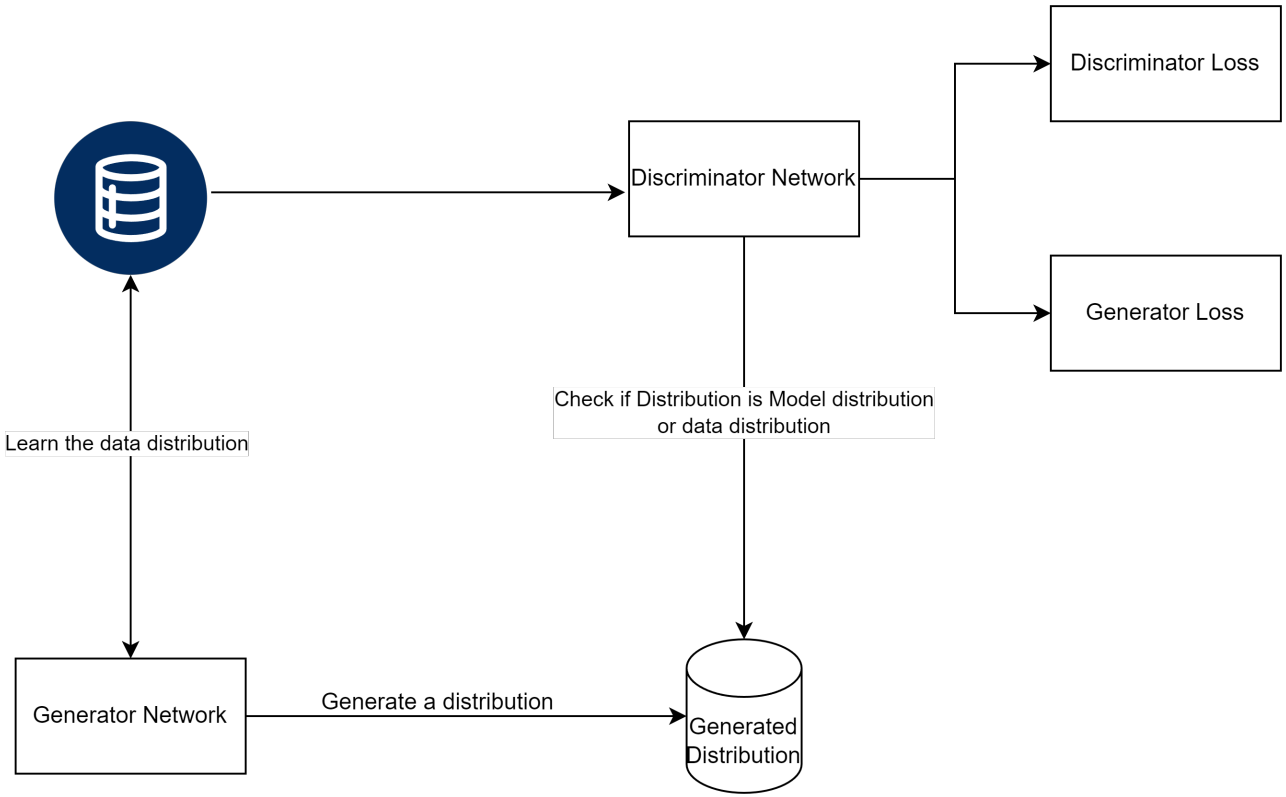

Figure: How the GAN Works

Image fusion using GAN

- For remote sensing data, raw GAN is not used; specialized GANs such as Unmixing-based Multi-attention GAN **Su2023**, QIS-GAN **Zhu2023**, SwinGAN **Zhu2023a**, Physics-based GAN **Xiao2021** are some State of the art techniques.
- There has not been much work done in the domain of Multispectral-hyperspectral spatial-spectral image fusion using GAN other than the papers mentioned before.

Image fusion using GAN contd...

- The state of the art techniques like QIS-GAN, Unmixing-based GAN, SwinGAN were designed and trained on systems that had upwards of 64 GB RAM, and with GPU support (thousands of CUDA cores).
- What I will do:
  - Try running vanilla GAN for image fusion (with required modifications)
  - Once successful, implement QIS-GAN as it is lightweight.

Data

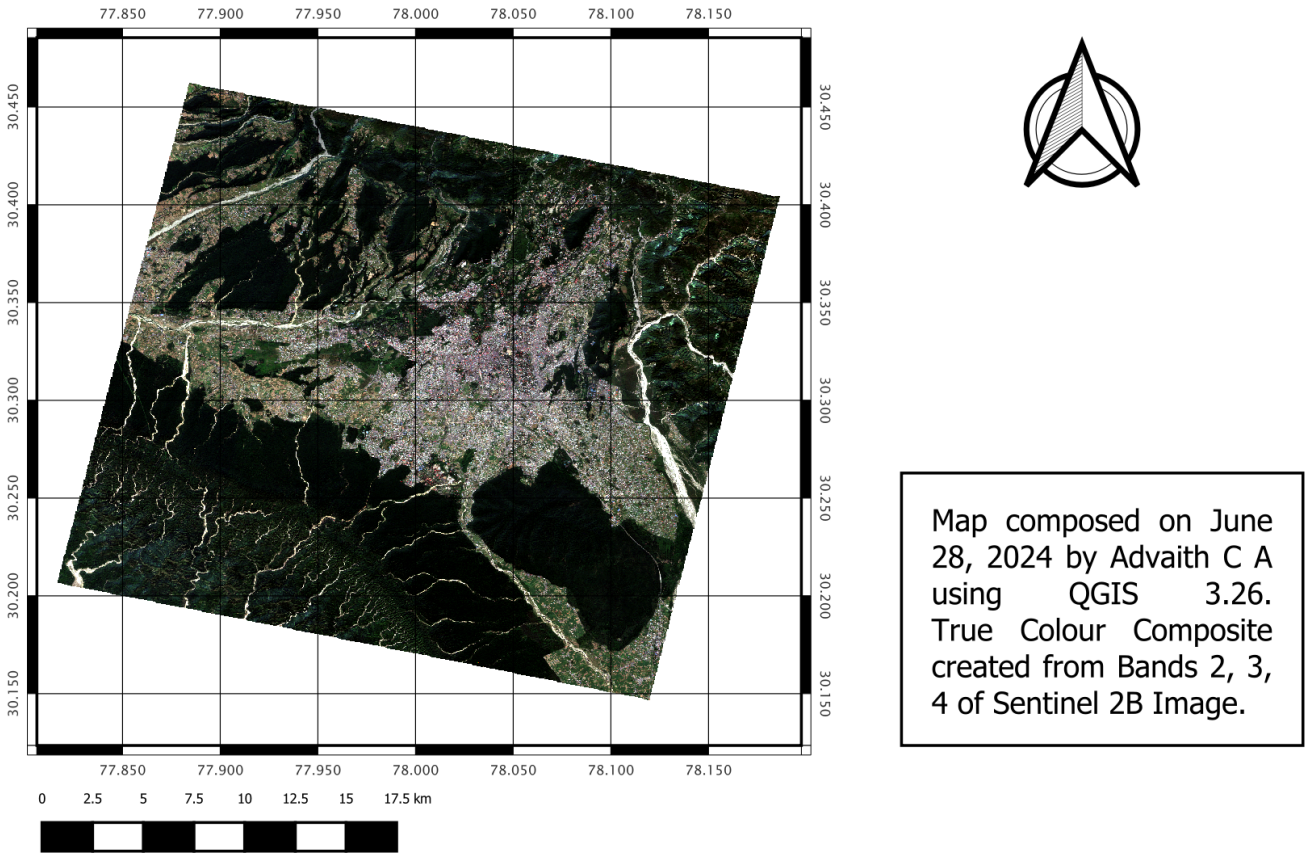

Figure: The sentinel 2 image of Dehradun area

Data

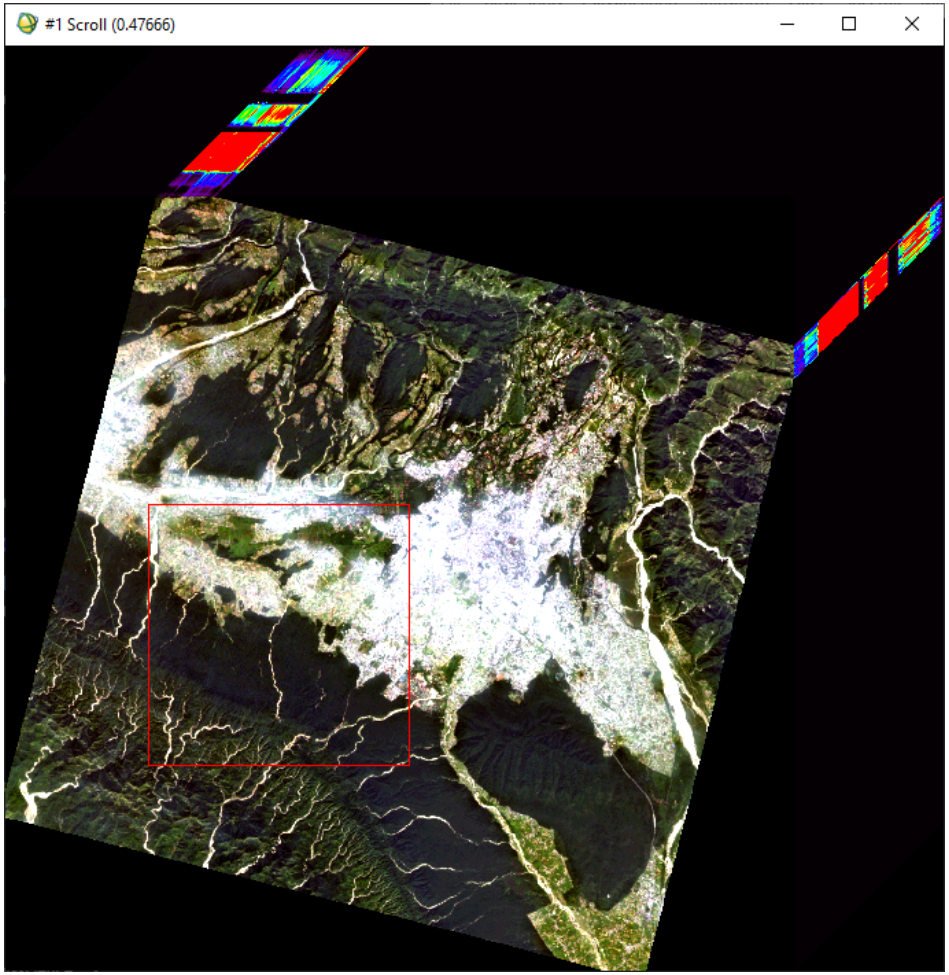

Figure: Screenshot of hyperspectral data of the same area, visualized as hypercube in ENVI class 5.0

GAN vs Conventional

Generative Adversarial Networks	**Conventional**
Can preserve spatial and spectral properties	There are chances for degradation
Less susceptible to noise	Noise can ruin the process
Adapts to different data distributions	There is no real "adaptation" to the data

Table: Comparison of GAN and Conventional methods for fusion.

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