CE671A Lab 4

Aadya Umrao
210003
Civil Engineering
aadyau21@iitk.ac.in

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1 Introduction

The aim of this lab is to explore key concepts in remote sensing image processing, specifically linear stretching, color composites, color representation, and Look Up Tables (LUTs). Through hands-on work with MATLAB and imagery from the LISS 3 sensor, the lab provides an opportunity to understand how different colors are represented in an image and how Digital Numbers (DNs) across different bands influence color composites. By utilizing band combinations, students can generate various RGB composites, and through linear stretching, they will learn how to enhance image contrast. The lab also involves creating a Look Up Table by comparing the RGB values before and after stretching for selected pixels, enabling a deeper understanding of color transformations and their impact on image interpretation.

2 Methodology

2.1 Procedure-

Prepare the Data:

- Begin by accessing the `L4_tiff` folder that contains three images, which correspond to band 2, band 3, and band 4 of the LISS 3 sensor. These images are named `imagery1.tif`, `imagery2.tif`, and `imagery3.tif`.
- Load these images into MATLAB for further analysis.

Understand the LISS 3 Sensor:

- Read up on the specifications of the LISS 3 sensor. This sensor captures images across multiple bands. Band 2 represents the Green region of the spectrum, Band 3 corresponds to Red, and Band 4 captures the Near-Infrared (NIR) region. Understanding this will help in assigning appropriate bands to the RGB channels for visualization.

Display FCC Image:

- In MATLAB, create a false color composite (FCC) image. For FCC, assign the NIR band (Band 4) to the Red channel, the Red band (Band 3) to the Green channel, and the Green band (Band 2) to the Blue channel.

Examine Pixel Values:

- As the FCC image is displayed, use MATLAB's interactive tools, such as the `impixelinfo()` function, to check the Digital Numbers (DNs) or pixel values for different regions in the image.

- Analyze the spread of pixel values across different bands. Typically, different bands will have different ranges of DNs, influenced by factors such as atmospheric conditions and surface reflectance properties.

Experiment with Different RGB Band Combinations:

- Explore other possible band combinations in the RGB channels. For example, try combinations such as Band 4 (NIR) in Red, Band 2 (Green) in Green, and Band 3 (Red) in Blue, etc.
- Given three bands, the possible combinations for RGB channels are six (3 factorial: 3! = 6).

Apply Linear Stretching:

- Perform linear stretching on each band individually to enhance the contrast of the image.
- Use the histogram of each band to determine appropriate `Min` and `Max` values, allowing you to clip the extreme values and focus on the most informative range.

Display Stretched FCC Image:

- After applying linear stretching, display the stretched FCC image. This enhanced version should show improved contrast and detail compared to the original.

Select and Zoom into Specific Pixels:

- Identify five specific pixels in the normal FCC image across different surface types, such as the top of a workshop roof, water body, vegetation, road, and concrete floor.
- Zoom in on these pixels until the image is pixelated, enabling precise selection of the pixel in MATLAB.

Create a Table of RGB Values:

- Record the RGB values for the selected pixels using MATLAB's interactive tools.
- Use an online color blender tool, to determine the corresponding color for each set of RGB values.

Calculate Stretched RGB Values:

- Apply the linear stretching formula to each of the RGB values for the selected pixels.
- Compare the new RGB values with the stretched FCC image and find the corresponding colors using the blender tool.
- Document the original and stretched RGB values and colors in a table. This table serves as a Look Up Table (LUT) for mapping pixel values to colors before and after stretching.

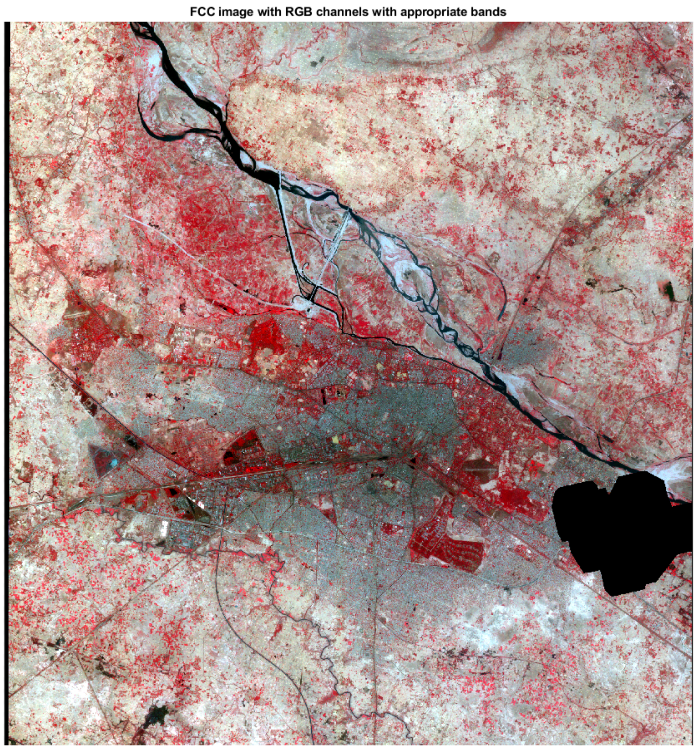
2.2 Results-
2)
The LISS-3 sensor on board the IRS-P6 (Resourcesat-1) satellite provides images in four spectral bands:

- **Band 1 (Green)**: 0.52 - 0.59 µm
- **Band 2 (Red)**: 0.62 - 0.68 µm
- **Band 3 (Near-Infrared, NIR)**: 0.77 - 0.86 µm
- **Band 4 (Shortwave Infrared, SWIR)**: 1.55 - 1.70 µm

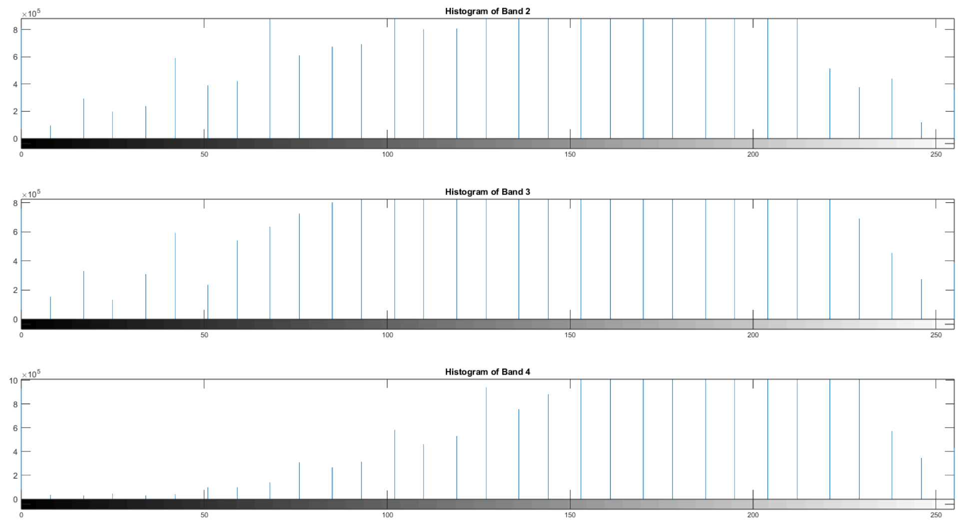
Since we have images of bands 2, 3, and 4:

- Band 2 (Red) will be displayed in the green channel.
- Band 3 (NIR) will be displayed in the red channel.
- Band 4 (SWIR) can be displayed in the blue channel for FCC.

3)



4)



Band 3 (NIR) – Red Channel:

- High pixel values (bright red) in the NIR band often indicate vegetation. Vegetation reflects strongly in the NIR range, making it appear bright red in the FCC image.

Band 2 (Red) – Green Channel:

- The red band is sensitive to chlorophyll, so moderate pixel values (green shades) can indicate areas with sparse vegetation or mixed land cover.

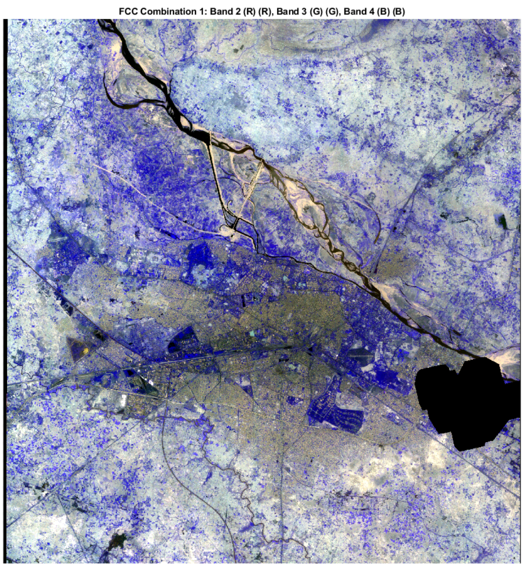
Band 4 (SWIR) – Blue Channel:

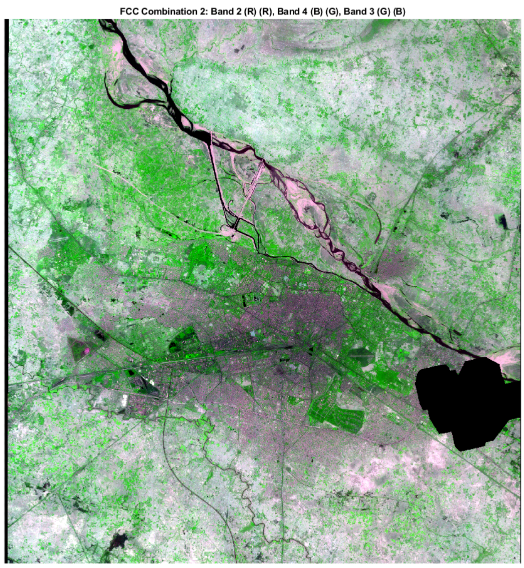
- The SWIR band is sensitive to moisture content. High pixel values in this band (light blue) may indicate water bodies or moist soil.

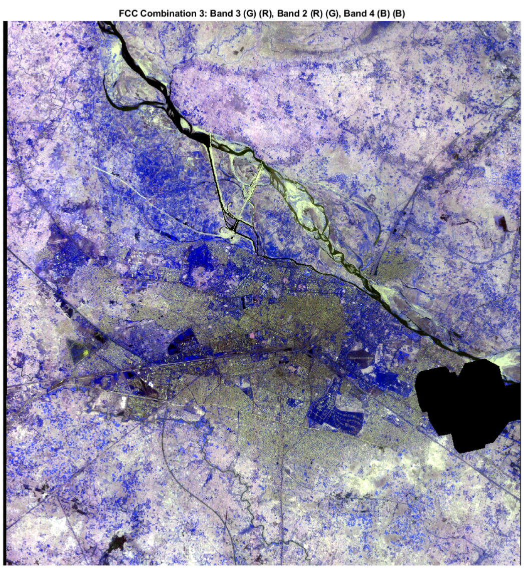
General Comments on Spread:

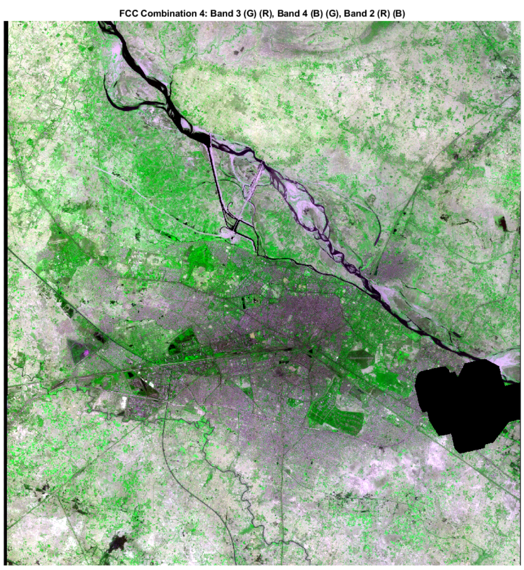
- **Vegetation Areas:** These areas will have high pixel values in the NIR band and moderate values in the Red and SWIR bands.
- **Urban Areas:** These will typically show moderate to low pixel values across all bands, as concrete and asphalt do not reflect strongly in these wavelengths.
- **Water Bodies:** Water absorbs most wavelengths and will have low pixel values in NIR and SWIR bands. In the Red band, water may show higher values depending on turbidity or suspended particles.
- **Soil and Bare Ground:** Bare soil might show moderate pixel values in the Red band and lower values in the NIR and SWIR bands.

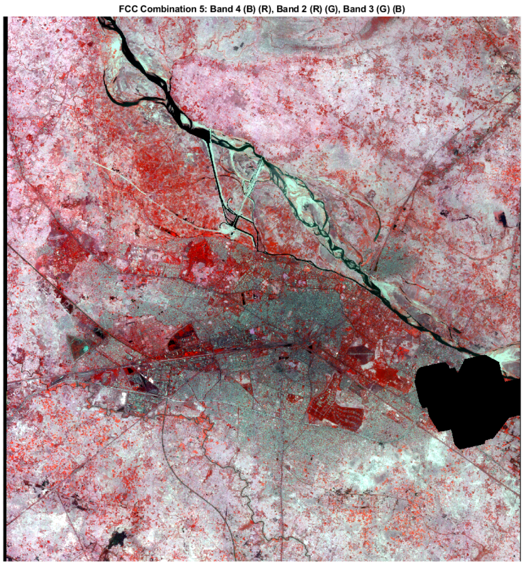
5)

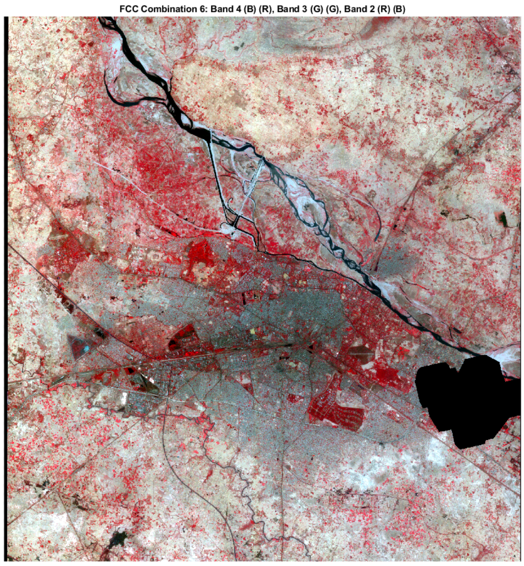






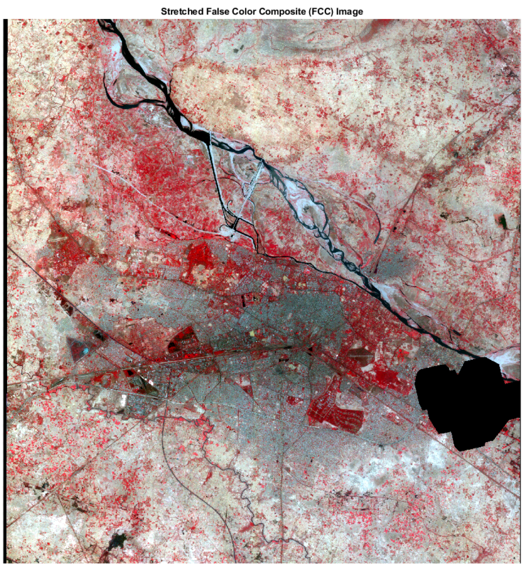






6 different type of combinations are possible

7) stretched image as fcc



10) Look-up Table

```
>> labb4
Original Band 2: Min = 0, Max = 255
Stretched Band 2: Min = 0, Max = 255
Original Band 3: Min = 0, Max = 255
Stretched Band 3: Min = 0, Max = 255
Original Band 4: Min = 0, Max = 255
Stretched Band 4: Min = 0, Max = 255
Pixel 1 - Address: (549, 2137), Original RGB: [170, 136, 102], Stretched RGB: [170, 136, 102]
Pixel 2 - Address: (2409, 3043), Original RGB: [178, 212, 127], Stretched RGB: [178, 212, 127]
Pixel 3 - Address: (2781, 1615), Original RGB: [204, 246, 255], Stretched RGB: [204, 246, 255]
Pixel 4 - Address: (2199, 3673), Original RGB: [93, 119, 127], Stretched RGB: [93, 119, 127]
Pixel 5 - Address: (3363, 613), Original RGB: [246, 238, 238], Stretched RGB: [246, 238, 238]
    pixel_number    pixel_address          Var3             rgb_values_from_image    color_from_blender    values_from_stretched_image    color_from_new_image_in_blender
    ____________    _____________    __________________    _____________________    __________________    ___________________________    _______________________________

         1          {[ 549 2137]}    {'Airstrip'        }      {[170 136 102]}          {'#AA8866'}             {[170 136 102]}                    {'#AA8866'}
         2          {[2409 3043]}    {'Roof'            }      {[178 212 127]}          {'#B2D47F'}             {[178 212 127]}                    {'#B2D47F'}
         3          {[2781 1615]}    {'Waterbody'       }      {[204 246 255]}          {'#CCF6FF'}             {[204 246 255]}                    {'#CCF6FF'}
         4          {[2199 3673]}    {'Vegetation'      }      {[ 93 119 127]}          {'#5D777F'}             {[ 93 119 127]}                    {'#5D777F'}
         5          {[ 3363 613]}    {'Residential Area'}      {[246 238 238]}          {'#F6EEEE'}             {[246 238 238]}                    {'#F6EEEE'}
```

Questions-
1. Three applications where different FCC combinations can be used-
Vegetation Health Monitoring:

- **FCC Combination:** NIR (Near-Infrared), Red, Green.
- **Description:** This FCC combination is widely used to assess vegetation health. Healthy vegetation reflects more in the NIR band and less in the red band, allowing differentiation between healthy and stressed plants. This application is essential for agriculture, forestry, and environmental monitoring.

Urban Area Mapping:

- **FCC Combination:** SWIR (Shortwave Infrared), NIR, Red.
- **Description:** This combination can be used for urban area mapping, identifying built-up regions, roads, and other infrastructure. The SWIR band helps differentiate between concrete and asphalt, while NIR assists in identifying vegetation within urban areas. This is useful for urban planning and disaster management.

Water Body and Wetland Mapping:

- **FCC Combination:** SWIR, NIR, Blue.
- **Description:** In this combination, water bodies and wetlands appear dark in the NIR and SWIR bands, making it easier to distinguish them from surrounding land. This application is crucial for water resource management, flood mapping, and wetland conservation.

2.
RGB Model (Red, Green, Blue):

- **Description**: RGB is a color model used primarily for digital displays like monitors, TVs, and projectors. Colors are created by combining red, green, and blue light. The more light you add, the closer the color gets to white, which is why it's called an additive color model.
- **Application**: Used in digital imaging, web design, and any scenario where light is the medium (e.g., screens).

CMYK Model (Cyan, Magenta, Yellow, Black):

- **Description**: CMYK is used for printing. It works by subtracting light from a white background. Cyan, magenta, and yellow are mixed to absorb (subtract) different wavelengths of light, leaving the desired color on the paper. Black (Key) is added for depth and contrast. This is known as a subtractive color model.
- **Application**: Used in color printing, packaging design, and any situation where pigments or inks are applied to a surface (e.g., magazines, brochures).

Additive vs. Subtractive Mixing:

- **Additive Mixing (RGB)**: Starts with black (absence of light) and adds light to create colors. The combination of all three primary colors at full intensity results in white.
- **Subtractive Mixing (CMYK)**: Starts with white (full spectrum of light) and subtracts light using pigments or inks to create colors. Combining all pigments ideally results in black, but in practice, it results in a muddy brown, so black ink (K) is added.

3.
Color Mapping and Correction:

- **Description:** LUTs are used to map input colors to output colors. This is essential for tasks like color correction, where a specific color balance is required across different devices (e.g., cameras, monitors, and printers). LUTs ensure that the same color is displayed or printed consistently, regardless of the device or medium.
- **Application:** Widely used in post-production of films, photography, and graphic design, where color grading and correction are crucial.

Image Enhancement:

- **Description:** LUTs are also used to enhance images by applying specific transformations. For example, an LUT can increase contrast, enhance specific colors, or apply a particular visual style to an image.
- **Application:** In medical imaging, LUTs are used to enhance the visibility of certain tissues or anomalies. They are also used in satellite imagery to highlight specific features like water bodies or vegetation.

3 Discussion

In this assignment, we utilized LISS 3 sensor data to create a False Color Composite (FCC) image by assigning the NIR, red, and SWIR bands to the red, green, and blue channels, respectively. This configuration highlighted vegetation in red due to its strong NIR reflectance, while urban areas and water bodies were distinguishable based on their reflectance in the other bands. By analyzing pixel values, we observed variations in reflectance across different land cover types, and linear stretching further enhanced these differences. Exploring different band combinations provided insights into how various features can be highlighted, reinforcing the importance of band selection and image enhancement in satellite imagery analysis.

4 Conclusion

In this lab assignment, the primary objective was to explore various remote sensing techniques using LISS 3 sensor data, focusing on creating False Color Composite (FCC) images and applying linear stretching to enhance image contrast. The results demonstrated that assigning the NIR band to the red channel effectively highlights vegetation, while other features like urban areas and water bodies were distinguishable based on their reflectance in the red and SWIR bands. By experimenting with different band combinations, we found that certain configurations could better highlight specific features, reinforcing the importance of careful band selection in remote sensing applications. Additionally, the use of linear stretching showed how contrast enhancement can reveal more detailed information about the surface features captured in the imagery.

5 References

https://www.usgs.gov/centers/eros/science/usgs-eros-archive-isro-resourcesat-1-and-resourcesat-2-liss-3

https://topex.ucsd.edu/rs/color.pdf

https://www.ni.com/docs/en-US/bundle/ni-vision-concepts-help/page/lookup_tables.html?srsltid=AfmBOoqNqxgAjOxUHJqbDX8LxNOGjP8QNl_XPMaV3nl0US2b7AzzgnUy