Exercise 6: Spectral Transformations and Convolution Operations

40 Points scaled to 20 Points

Introduction

In this exercise, you will explore principle component analysis, convolutional operations, and the tasseled cap transformation.

Objectives

- *Convert bands to principle components, interpret Eigenvectors, and determine percent of variance explained by principle component bands*
- *Perform mathematical operations corresponding to convolution operations*
- *Apply and interpret convolutional operations*
- *Perform a spectral conversion or Tasseled Cap Transformation to convert Landsat 8 OLI data to brightness, greenness, and wetness*

Prerequisite Materials

- Modules: Ratios and Spectral Enhancements
- Videos
  - Lab 5 and 6 Intro: https://youtu.be/QBF_K5_ei3g
  - PCA: https://youtu.be/UJRnUtN8x98
  - Convolution: https://youtu.be/-QXFhx_ig4c
  - Spectral Conversions: https://youtu.be/oBmD-zhI1Bw

Data

Here we describe the data provided in each map in the project file.

- Istanbul Map: Sentinel-2 MSI multispectral image for area around Istanbul, Turkey collected on 8/12/2020.
  - Band 1 = Blue
  - Band 2 = Green
  - Band 3 = Red
  - Band 4 = Red Edge 1
  - Band 5 = Red Edge 2
  - Band 6 = Red Edge 3
  - Band 7 = NIR

- Band 8 = NIR (Narrow)
- Band 9 = SWIR 1
- Band 10 = SWIR 2

❖ Innsbruck Map: RGB aerial image for an area near Innsbruck, Austria. This image is from the Inria dataset (https://project.inria.fr/aerialimagelabeling/) (Band 1 = Red, Band 2 = Green, Band 3 = Blue).

❖ Sand Fire Map: The 2016 Sand Fire occurred in the Angeles National Forest east of Los Angles, California. It began on July 22, 2016. The fire was not contained until August 3, at which point it had burned an estimated ~35,000 acres. You have been provided with two Landsat 8 Operational Land Imager (OLI) scenes. The pre-fire scene (**sand_fire_pre_4_17_2015.tif**) was collected on April 17th, 2015 while the post-fire scene (**sand_fire_post_4_12_2017.tif**) was collected on April 22nd, 2017. These data have been processed to surface reflectance.

- Band 1 = Blue Edge
- Band 2 = Blue
- Band 3 = Green
- Band 4 = Red
- Band 5 = NIR
- Band 6 = SWIR1
- Band 7 = SWIR2

Istanbul

Figure 1. Sentinel-2 MSI multispectral image of area around Istanbul, Turkey.

- ❖ Calculate 10 principle component bands from the 10 original bands. Make sure to obtain the output data file and the output raster.

Question 1. What is the purpose of performing principle component analysis on an image? (4 Points)

Question 2. What percent of the variance in the original bands is explained by the 1st principle component? (2 Points)

Question 2. What percent of the variance in the original bands is explained by the 2nd principle component? (2 Points)

Question 3. What percentage of the variance is collectively explained by the 1st through 3rd principle components? (2 Points)

Question 4. Using the Eigenvectors obtained, calculate the value for principle component 1 for a pixel with the following cell values: (4 Points)

B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
719	803	1526	1574	1631	1487	1610	1689	1984	1796

Convolution

The following grid represents an array of DN values making up a small proportion of an image. The following questions will ask you to find the value at the center cell position when a kernel with a defined size and set of values is positioned over the center cell.

41	61	83	101	83
143	137	162	129	131
118	122	128	132	127
201	198	191	194	207
240	231	217	222	226

-1	-1	-1	-1	-1
-1	-1	-1	-1	-1
-1	-1	24	-1	-1
-1	-1	-1	-1	-1
-1	-1	-1	-1	-1

Question 5. What is the cell value for the center cell in the window when the provided kernel is applied? (2 Points)

+1	+2	+1
0	0	0
-1	-2	-1

Question 6. What is the cell value for the center cell in the window when the provided kernel is applied? (2 Points)

1/25	1/25	1/25	1/25	1/15
1/25	1/25	1/25	1/25	1/25
1/25	1/25	1/25	1/25	1/25
1/25	1/25	1/25	1/25	1/25
1/25	1/25	1/25	1/25	1/25

Question 7. What is the cell value for the center cell in the window when the provided kernel is applied? (2 Points)

-1	0	1
-2	0	2
-1	0	1

Question 8. What is the cell value for the center cell in the window when the provided kernel is applied? (2 Points)

Innsbruck

Figure 2. Aerial RGB image of area near Innsbruck, Austria.

- Use the Convolution function from the ArcGIS Pro Raster Functions to apply the four kernels above to the Innsbruck image. You will need to build the kernels as a user-defined kernel.
- Extract the resulting cell values at the point location provided (**Innsbruck_point.tif**) to answer the following questions. This can be accomplished using the Extract Multi Values to Points Tool.

Question 9. What was the Band 1 value at the point location when applying the filter from Question 5? (2 Points)

Question 10. What was the Band 2 value at the point location when applying the filter from Question 6? (2 Points)

Question 11. What was the Band 2 value at the point location when applying the filter from Question 7? (2 Points)

Question 12. What was the Band 3 value at the point location when applying the filter from Question 8? (2 Points)

Sand Fire

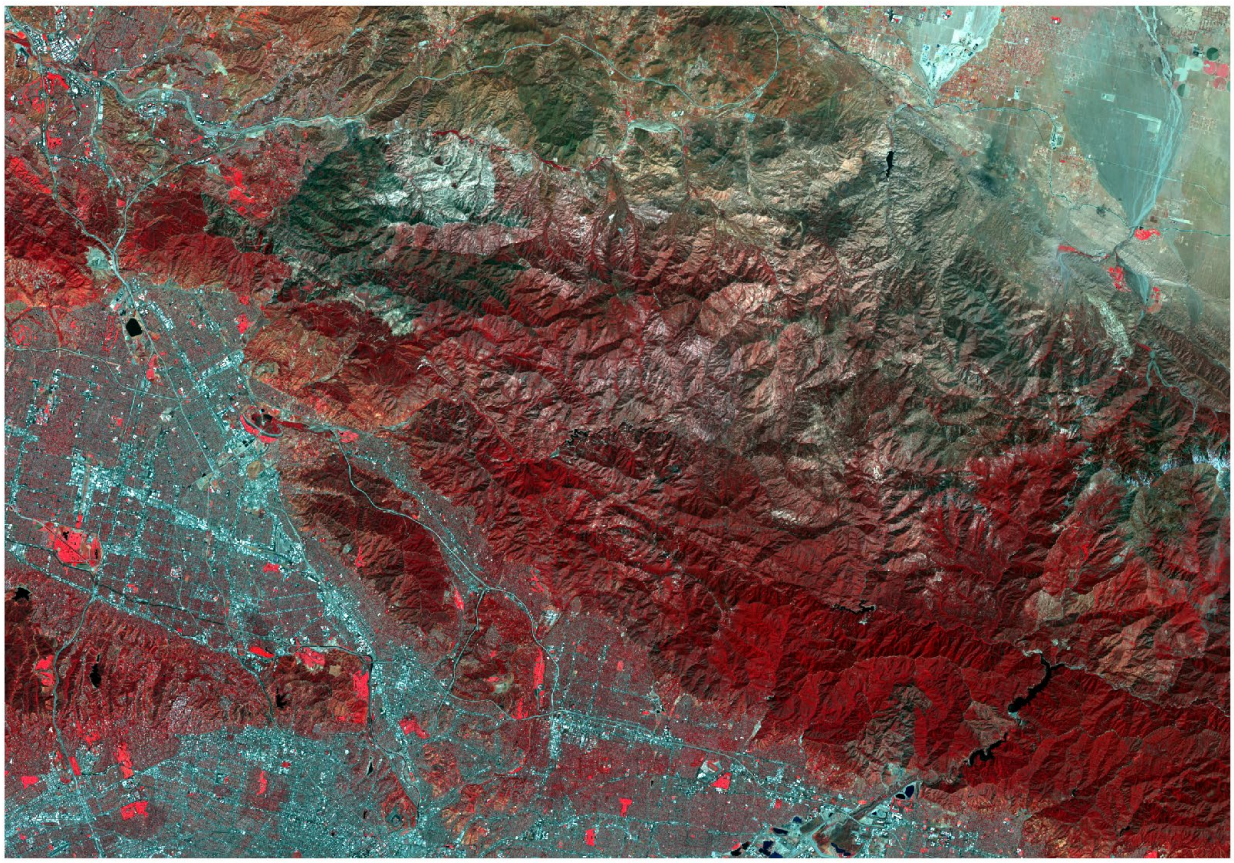

Figure 4. Post-fire Landsat-8 image of Sand Fire in California.

- Perform a Tasseled Cap transformation of the post-fire Landsat 8 OLI image using the Spectral Conversion function from the ArcGIS Pro Raster Functions. Note that Band 1 (Blue Edge) is not used, so it should be set to zero for all components. The needed Landsat 8 Tasseled Cap coefficients are available in the Ratios and Enhancements lecture module.

Deliverable 1: Create a map layout that shows the Tasseled Cap transformation result as a composite (Red = Brightness, Green = Greenness, Blue = Wetness). Include a scale bar, north arrow, title, and citation for the Landsat program. The result will be partially judged based on neatness, use of space, and data symbology. (10 Points)