**Lab Report**

Title: The Order of the Universe: Space and Time Cubes

Notice: Dr. Bryan Runck

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**Project Repository:** https://github.com/CeceliaAi/GIS5572/tree/master/Lab2

**Abstract**

*<Delete this text in light grey throughout>*

*250 words max. Clearly summarize the following major sections. Each gets one or two sentences.*

The main problem of this lab is to explore 3D data and spacetime cube data with Python. In the first part, we will download, examine, transform, and export LiDAR data. In the second, we will download monthly precipitation data and use it to create a spacetime cube and timeseries animation. The data used will be an .laz file of the Central Lakes from MnGeo, and .bil files of precipitation data from PRISM. Both parts of the lab will first require and ETL that downloads and transforms the data. In Part 1, we will then create a layout of the visualizations and export them. We will also use ArcPro to examine the raw LiDAR data. In Part Two, we will use arcpy to build the spacetime cubes. In both parts, our results will be an export of a file. Part 1 will be two PDF files, and Part 2 is a time series animation in ArcPro. The results will be verified by error-free code and the correct output. In this lab we will learn how to display and manipulate 3D data, so the process will answer the main problem, rather than the output specifically.

**Problem Statement**

*Describe the specific problem and the context. Provide an illustrative figure and/or context map here. In the table, translate the qualitative problem statement elements into specific requirements for the analysis.*

This lab has two parts which both, broadly speaking, deal with 3D data. Part 1 works with raster data derived from LiDAR, and Part 2 with spacetime data derived from annual measurements. The main problem is to download this data and export it in another form. Part 2 has the additional step of creating an animation.

*Table 1. Data*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **#** | **Requirement** | **Defined As** | **Spatial Data** | **Attribute Data** | **Dataset** | **Preparation** |
| 1 | Convert to DEM and TIN | Take raw LiDAR data to convert it into different raster formats | Point cloud data |  | [Mn GeoSpatial Commons](http://ftp.lmic.state.mn.us/pub/data/elevation/lidar/projects/central_lakes/block_1/laz/) | Convert from LAZ to LAS |
| 2 | Make a spacetime cube | Convert monthly normal data of precipitation into a 3D format | Precipitation normals data over 30 years | Time data needs to be added in a new field | [PRISM](https://prism.oregonstate.edu/normals/) | Convert to TIFF |

**Input Data**

*Describe the data in two paragraphs max. Fill out the table.*

The data is an .LAZ file from MN DNR of XXXX. The data for Part 2 are the annual 30-Year normal data for precipitation from PRISM. They are .bil files in zip files.

*Table 2. Data*

|  |  |  |  |
| --- | --- | --- | --- |
| **#** | **Title** | **Purpose in Analysis** | **Link to Source** |
| 1 | Central Lakes .las | To learn about working with LiDAR data | [Mn GeoSpatial Commons](http://ftp.lmic.state.mn.us/pub/data/elevation/lidar/projects/central_lakes/block_1/laz/) |
| 2 | 30-Year Normals .bil | To convert to 3D animation | [PRISM](https://prism.oregonstate.edu/normals/) |

**Methods**

*Include a data flow diagram or screenshot from model builder. Do references in line (Rammankutty, 2033). Document any and all steps that you did to the input data in the data flow diagram. Provide natural language description of the most important steps, giving a narrative arc and provide well formatting screenshots with a boarder and centered throughout.*

In Part 1 of the lab, first we wrote an ETL to download an ETL file, and then transform it into an .LAS, and then into a DEM and a TIN. We saved those files to our local machines, and then moved into ArcPro to create two layouts. I then used Python code to download PDFs of the layouts (Figure 1). Finally, we examined the raw LiDAR data in the ArcPro viewer.

*Figure 1. Part 1 data flow diagram.*

Continuing in Part 1, we wrote another ETL to get data from PRISM. The data was downloaded as a .BIL file and then transformed into a spacetime cube. This was exported to the local computer and then put into a timeseries animation (Figure 2).

*Figure 2. Part 1 data flow diagram.*

**Results**

*Show the results in figures and maps. Describe how they address the problem statement.*

*Follow best practice for map design, coloring, etc.*

The results are two PDF outputs from Part 1 (Figure 4), and an animation in ArcPro from Part 2 (Figure 5). However, our problem was not necessarily the output but the process of working with 3D data. So the data analysis (Figure 6) did not have an output because it was more exploratory.

Figure 4.

*[SCREENSHOT 1, 2, 3]*

**Results Verification**

*How do you know your results are correct? This can be a qualitative or quantitative verification.*

We can verify our results by looking at the exported PDFs and spacetime cubes. I am not sure how to tell if the spacetime cubes are correct.

**Discussion and Conclusion**

*What did you learn? How does it relate to the main problem?*

I learned how to manipulate .LAZ files, including converting to different file types and performing analysis in 2D and 3D. The features for working on LiDAR in 2D are XXXXXX. The features for working on LiDAR in 3D are XXXXXX.

In the final part of the lab, I made another ETL and created spacetime cubes. This was the most arcane section for me. Converting the files was straightforward, but obtaining the correct files in Python, where I was not able to visualize them or check their metadata, meant I wasn’t sure I had the correct data, or all of the data I needed. Though the cubes drew correctly, it was hard to tell if they were in the right place or otherwise formatted properly. The animation of the timeseries also appeared to be correct but it was hard to verify that from just a visual examination. All of these things relate to the main problem, which was to explore and analyze 3D data.

**References**

Buie, L. (2020, February 11). Explore your raster data with Space Time Pattern Mining. *ArcGIS Blog*. <https://www.esri.com/arcgis-blog/products/arcgis-pro/analytics/explore-your-raster-data-with-space-time-pattern-mining/>

ESRI. (n.d.). *Tutorial: Getting started with arcpy.mp* [Documentation]. Retrieved February 14, 2021, from <https://pro.arcgis.com/en/pro-app/latest/arcpy/mapping/tutorial-getting-started-with-arcpy-mp.htm#ESRI_SECTION1_CEE9D43FE3B14F8AA9F0B109E9E8F766>

Lenhardt, J. (2020, December 17). How to create multidimensional raster data to use in ArcGIS Pro. *ArcGIS Blog*. <https://www.esri.com/arcgis-blog/products/arcgis-pro/imagery/create-multidimensional-raster-data/>

*Manage Multidimensional Raster (Multidimension)—ArcGIS Pro | Documentation*. (n.d.). Retrieved February 28, 2021, from <https://pro.arcgis.com/en/pro-app/latest/tool-reference/multidimension/manage-multidimensional-raster.htm>

*Use Arcade expressions with Calculate Field—Portal for ArcGIS | ArcGIS Enterprise*. (n.d.). Retrieved February 28, 2021, from <https://gis.fema.gov/arcgis/help/en/portal/latest/use/geoanalytics-calulate-field-expression.htm>

**Self-score**

|  |  |  |  |
| --- | --- | --- | --- |
| **Category** | **Description** | **Points Possible** | **Score** |
| **Structural Elements** | All elements of a lab report are included **(2 points each)**:  Title, Notice: Dr. Bryan Runck, Author, Project Repository, Date, Abstract, Problem Statement, Input Data w/ tables, Methods w/ Data, Flow Diagrams, Results, Results Verification, Discussion and Conclusion, References in common format, Self-score | 28 | **28** |
| **Clarity of Content** | Each element above is executed at a professional level so that someone can understand the goal, data, methods, results, and their validity and implications in a 5 minute reading at a cursory-level, and in a 30 minute meeting at a deep level **(12 points)**. There is a clear connection from data to results to discussion and conclusion **(12 points)**. | 24 | **24** |
| **Reproducibility** | Results are completely reproducible by someone with basic GIS training. There is no ambiguity in data flow or rationale for data operations. Every step is documented and justified. | 28 | **28** |
| **Verification** | Results are correct in that they have been verified in comparison to some standard. The standard is clearly stated **(10 points)**, the method of comparison is clearly stated **(5 points)**, and the result of verification is clearly stated **(5 points)**. | 20 | **20** |
|  |  | 100 | **100** |