COMPUTATIONAL URBAN DESIGN TO CREATE A GENDER-INCLUSIVE CAMPUS

An ArcGIS Workflow for Automatic Segmentation of Gender-inclusive Physical Features from LiDAR Data

A Case Study of the University of Calgary Main Campus

Hawjin Falahatkar, M.Sc. Student in Geography, the University of Calgary

MOTIVATION

The outdoor places of university campuses are critical urban places due to their role in supporting students' everyday ordinary activities, life and education experiences which leads to more sense of belonging to the university, satisfaction, and quality of life. It is highly crucial that everyone feels safe, welcomed, included, comfortable, and not discriminated against by their differential identities, like gender, while being on campus.

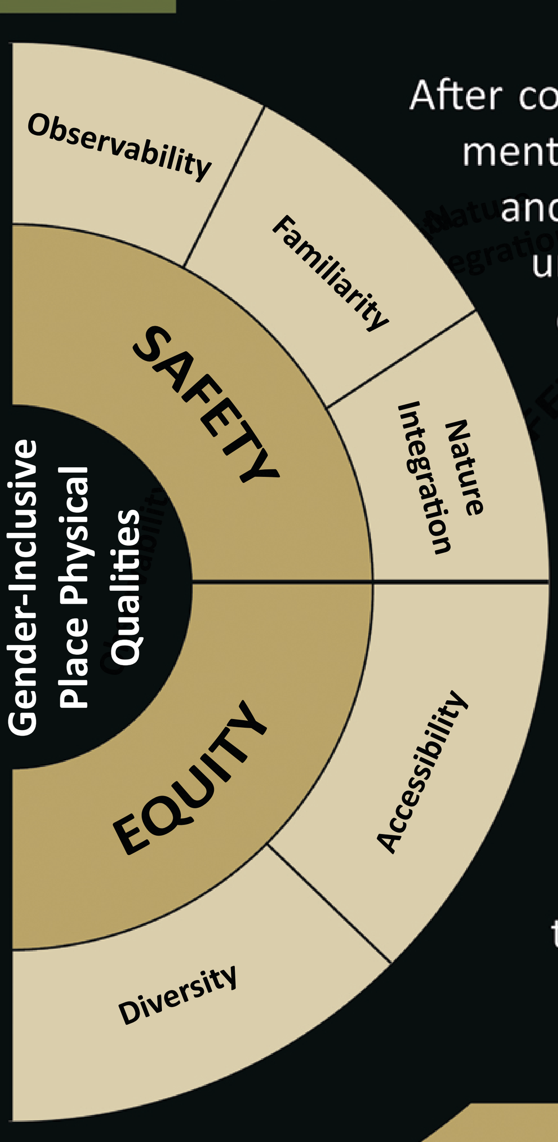
Therefore, the main goal of this research is to assess the gender inclusion of the University of Calgary's main campus outdoor places through a computational urban design analysis for identifying, analyzing, and measuring the campus gender-inclusive physical features employing ESRI technology.

To achieve this goal, first, gender-inclusive physical features of the urban place are identified and then they are mapped, measured and analyzed to conduct the computational urban design analysis.

RESEARCH METHODOLOGY

First, place qualities and physical features that promote gender inclusiveness are identified by searching for feminist spatial patterns. **Second**, based on the result of step 1, data requirements for assessing UCalgary campus gender inclusion are determined including the data types needed for the analysis in GIS language. **Third**, a variety of datasets, like shapefiles, images, and LiDAR, are collected to cover all the gender-inclusive physical features. **Finally**, employing ArcGIS Pro manual and automatic (deep learning) capabilities, a computational urban design analysis will be conducted to process, store, integrate, manage, and visualize these multiple datasets in order to assess the level of gender inclusion of the UCalgary campus.

Gender-Inclusive Place Qualities



After conducting a thematic analysis on secondary documents about gender-place relations, spatial qualities and related physical features that affect the way urban places include and welcome all genders were extracted. According to the thematic analysis of results, two general themes were identified: safety and equity. Concepts relevant to safety are observability, familiarity, and nature integration, and concepts relevant to equity are accessibility and diversity.

Each concept includes their physical features which, in the next step, are translated into GIS language by defining a mutually exclusive classification system for saving gender-inclusive feature classes and attributes.

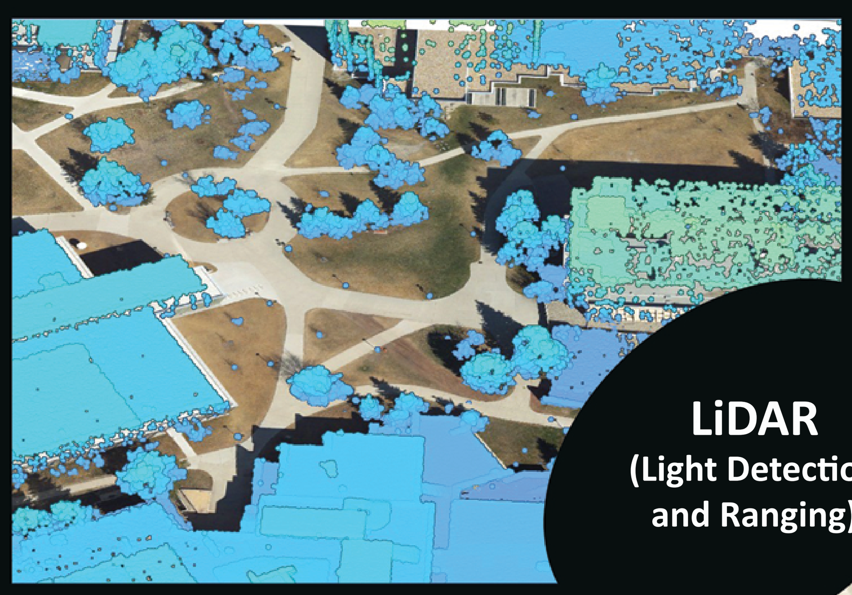
Data Requirements

- Building (line)
- Ground (polygon)
- Vegetation (point)
- Bench (point)
- Landmark (point)
- Transit Station (point)
- Public Toilet (point)
- Visual Barrier (point)
- Streetlight (point)
- Empty Lot (point)

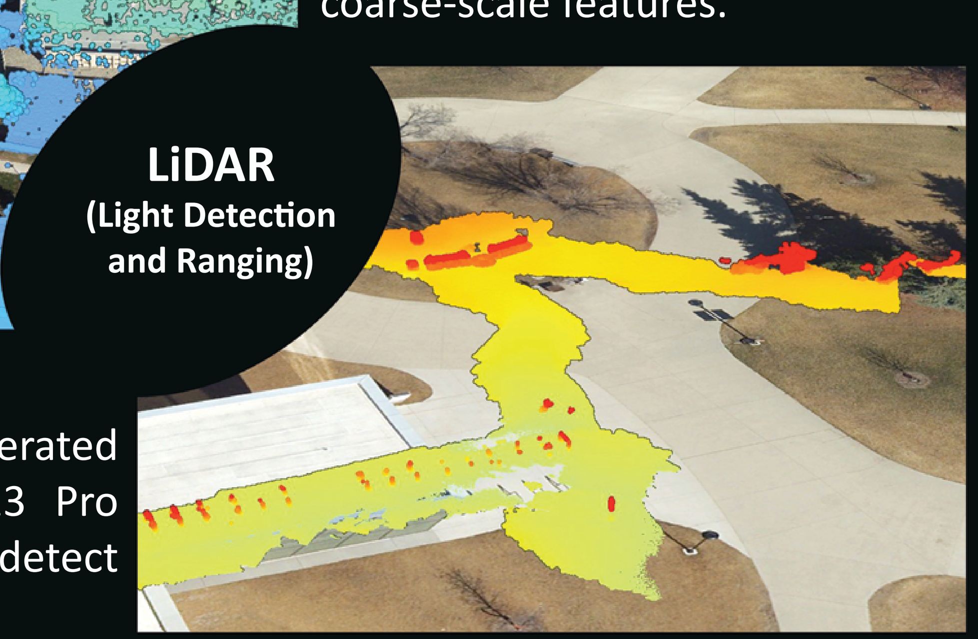
There is a need to collect data on these features and their attributes, process the data, and integrate them within ArcGIS Pro.

Here, the process of collecting and processing data on "streetlight" feature will be explored. The attributes related to streetlight are location, type, height, and illumination.

Data Collection



Aerial LiDAR data of UCalgary main campus by the University of Calgary Spatial and Numeric Data Services (SANDS) to detect coarse-scale features.



Mobile LiDAR data generated persobally using iPhone 13 Pro Max LiDAR scanner to detect fine-scale features.

LiDAR DATA SEGMENTATION

Method

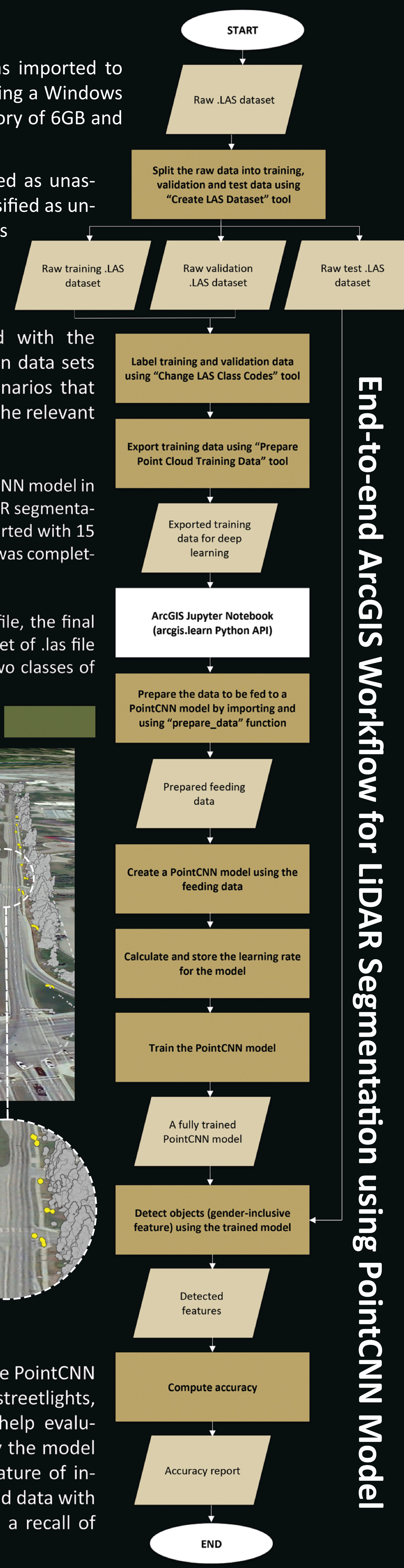
High quality LiDAR data in the form of .las files was imported to ArcGIS Pro licensed with the 3D Analyst extension using a Windows machine with an NVIDIA GPU with a dedicated memory of 6GB and 16GB RAM.

The LiDAR data set had originally two classes labelled as unassigned and ground which the ground class was reclassified as unassigned to abstract away as many irrelevant variables as possible and train a focused model that can execute and label the points with the highest efficiency.

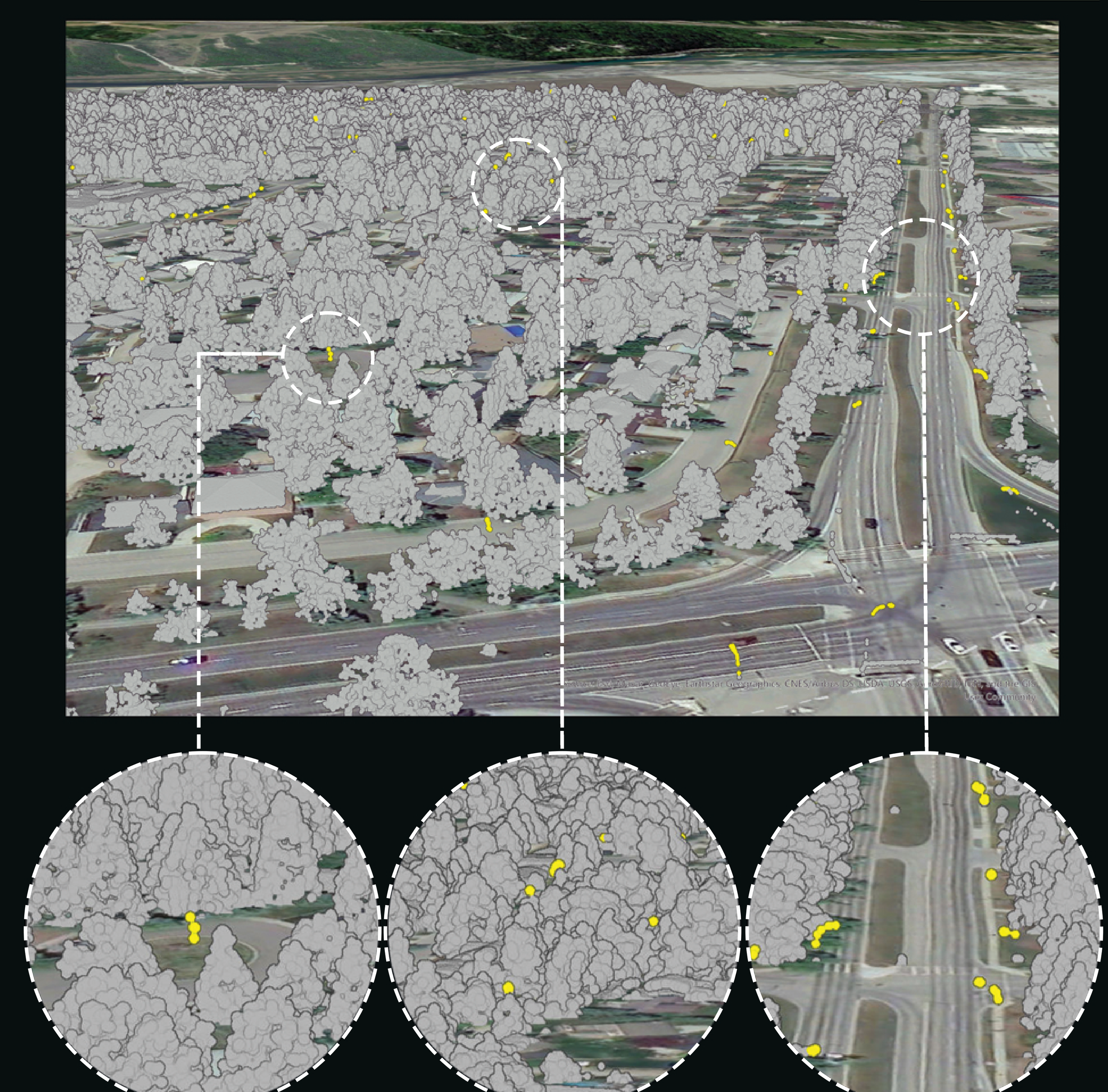
Two subsets of the data were manually labelled with the high-value assets to act as the training and validation data sets while trying to capture a diverse-enough set of scenarios that represent the full extent of the study area. Such that the relevant points as streetlights were labelled as a distinct class.

After preparing the point cloud data for training, the PointCNN model in the arcgis.learn module was used and fully trained for LiDAR segmentation with learning rate of about 0.004. The training was started with 15 epochs and early stopping was enabled which the training was completed at epoch 12.

After training and saving the PointCNN model as a .dlpk file, the final step was to run the newly trained model against the full set of .las file to segment the point cloud data of the study area into two classes of "streetlight" and "background".



Preliminary Result



Precision Metrics

	Background	Streetlight
Precision	0.999940	0.52658
Recall	0.987134	0.967546
F1_score	0.998535	0.689387

To evaluate how the PointCNN model can detect streetlights, precision metrics help evaluate how accurately the model can predict the feature of interest. Comparing the point in the resulting point cloud data with streetlight label leads to a precision of 0.52658 and a recall of 0.967546.

FUTURE WORK

The future work is to complete processing all datasets using ArcGIS Pro and integrate them in a GIS geodatabase to map gender-inclusive physical features in UCalgary campus outdoor places. The final results of this research project include:

1. An interactive map of gender-inclusive physical features for UCalgary campus outdoor places.
2. A zoning map showing different zones of UCalgary campus outdoor places based on different levels of gender inclusion.
3. An Esri dashboard to publish the result publicly.

CONCLUSION

ESRI technology provides an outstanding platform to conduct data-driven methods in socio-spatial research studies and bridge the longstanding gap between qualitative-based (urban design and feminism research) and quantitative-based (data science) research scopes. Indeed, this platform is quite suitable for non-programmer scientists, like geographers, urban designers, urban planners, and architectures, and allows them to apply high-level quantitative techniques in their interdisciplinary research; something that was previously only possible for programmers and data scientists.

ACKNOWLEDGEMENTS

This work is based on my M.Sc. thesis at the University of Calgary. I would like to thank my supervisor, Dr. Victoria Fast, for her support and mentorship. This research is funded by SSHERC and New Frontier organizations based in Canada, but not a product of them.

For more information, visit the story map: