Paths to ADA-Compliance: The Performance and Cost Efficiency of Measurement Technologies that Support ADA-Mandated, Self-Evaluations of Pedestrian Rights of Way

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Introduction

- People with disabilities have rights based on the movement laws that defend their equality with all members of the society.
- The Americans with Disabilities Act (ADA) advocated for the rights of individuals with disabilities, provided satisfying services for individuals with disabilities to live within the community.
- A series of demanding compliances be required to evaluate the facilities in various levels.
- Roadway facilities' routine way of checking is usually timely and costly.

Introduction

- In the long term run, improving accessibility for people with disability may reduce paratransit demand response services.

- Improving accessibility is especially important given both the high costs of providing demand-response transit service.

- US Census Bureau estimates that 19.5 percent of Michigan's population will be 65 and older by the year 2030—an increase of 38.1 percent from 2015—whereas the total population of Michigan is projected to grow by less than one percent over the same period.

- It should also be noted here that improving accessibility via ADA compliance also brings benefits not only for a group of people with disabilities but the whole community at large

Introduction

The impact of measurement equipment on an analytical process

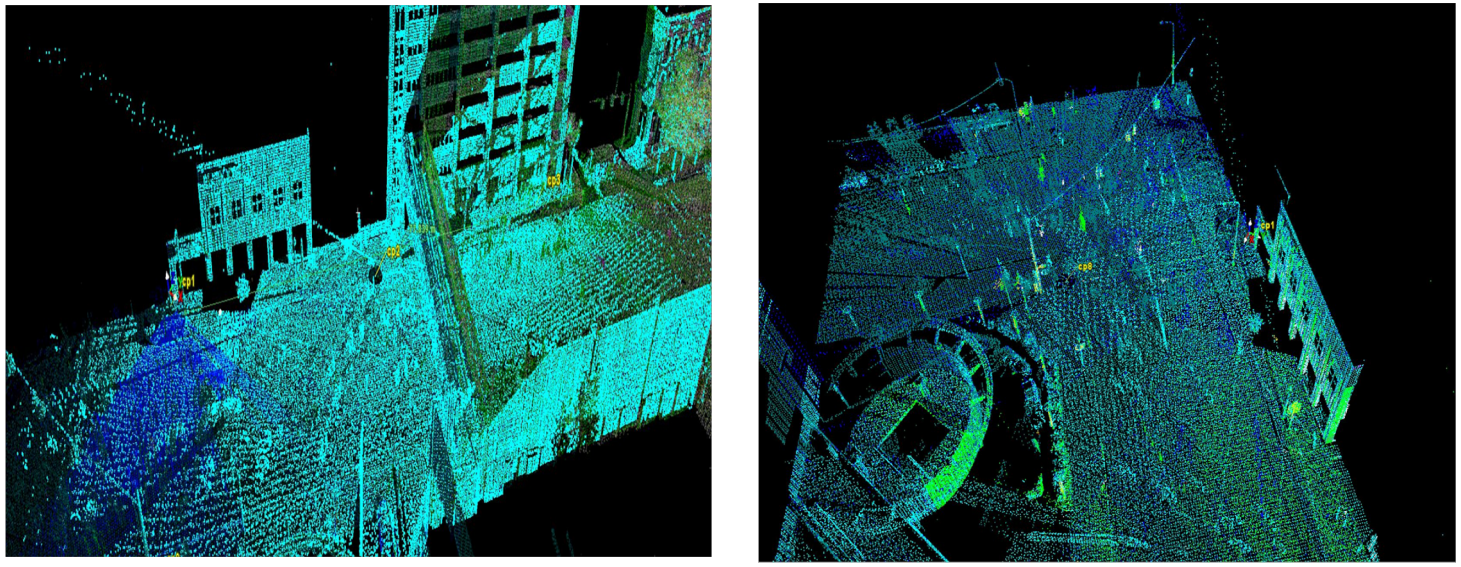
- Lidar is a surveying technology that collects spatial information.
- Lidar is widely used in 3D model creation in industrial sectors because of its high accuracy.
- Identifying accessibility compliance is the principal purpose of our attempts in developing an automatic method of analysis.
- Laser scanners could approximately collect a million points per second.
- One of the most stable and accurate items of measurement equipment that can provide X, Y, and Z coordinates is the laser scanner

Laser scanner used in data collection

Introduction

OBJECT DETECTION IN PCD

- Laser scanner collected point cloud data has been employed for surface modeling of as-built objects for an accurate mensuration of the objects .
- Massive PCD processing that helps recognize different naturally clustered groups or structures.
- The collected datasets need to be segmented to check these compliances.
- Each segment represents an object in the PCD.



3D Laser scanner's point cloud data

Introduction

THE ROLE OF AUTOMATION IN THE ANALYSIS PROCESS

- In scanning a public environment with many intersections and a thousand miles of sidewalks and curbs of various classifications and styles,
- The automatic identification and modeling will save the cost and time of many operating hours
- Isolating the noise and cutting back the number of errors in the data and unnecessary points to layers is one of the foremost and vital benefits of the automated method.
- Conducting automatic data analysis and reviews as the best practice.
- Boosting productivity through automated calculation.
- Improving the efficiency and accuracy of ADA evaluation

Introduction

ADA REQUIREMENTS FOR ACCESSIBLE ROUTES

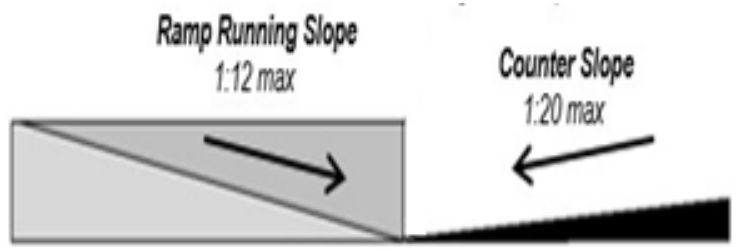
- The civil rights law that requires general protection for individuals with disabilities
- Ramps and curb ramps are required along accessible routes in public.

Accessibility Guidelines for Accessible Routes

Source	Maximum Allowable Running Grade without Handrails	Maximum Allowable Running Cross Slope	Maximum Allowable Vertical Change in Level
ADA Standards for Accessible Design 1 (US DOJ, 2010)	5.0%	2.0 %	6.4 (mm)

Accessibility Guidelines for Curb Ramps (CR)

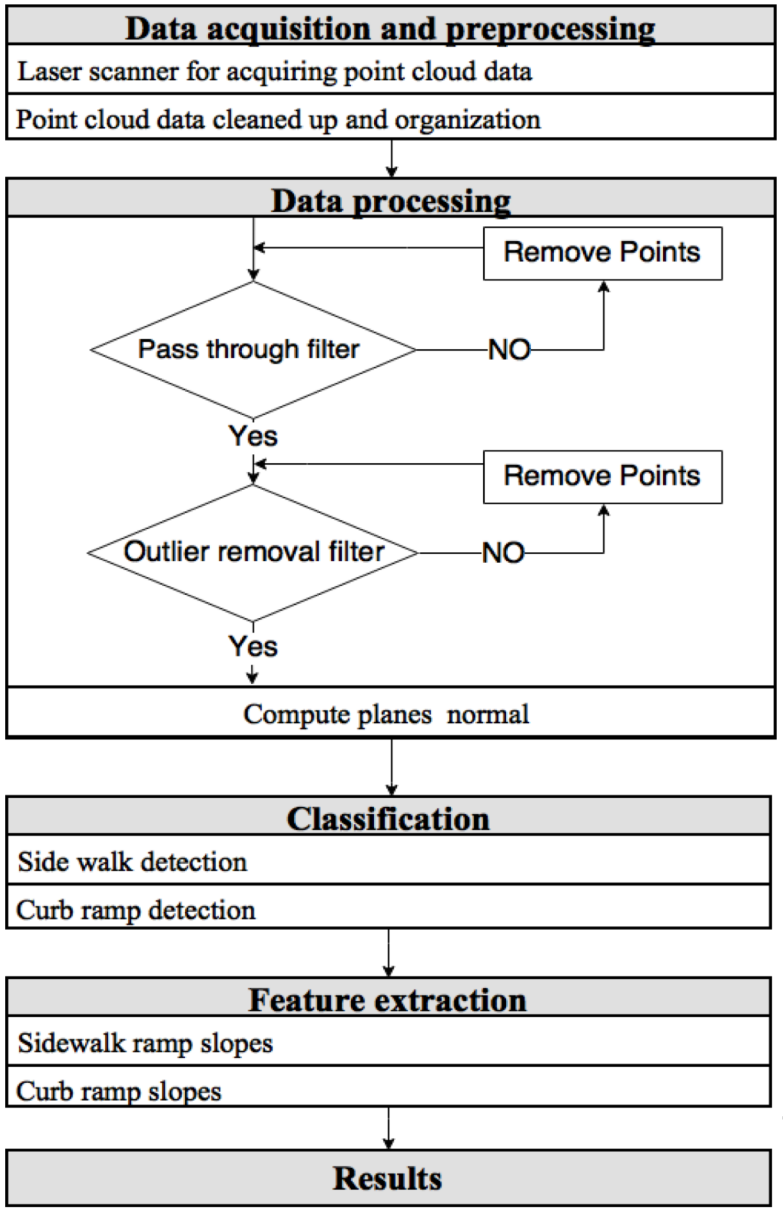
Source	Maximum Slope of Curb Ramps	Maximum Cross-Slope of Curb Ramps	Maximum Slope of Flared Sides
ADA Standards for Accessible Design (US DOJ, 2010)	8.33 %	2.0 %	10.0 %



Curb Ramps (CR) Slope's Details

Proposed method and algorithm

- Data acquisition and preprocessing
- Data processing
- Classification
- Feature Extraction



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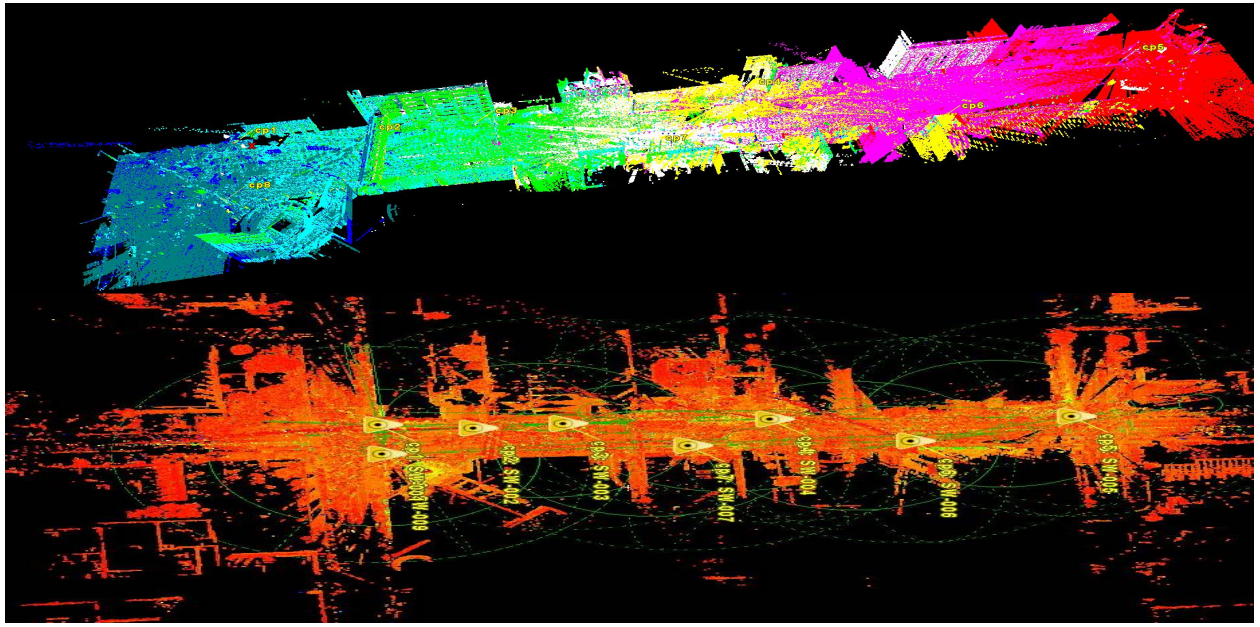
Data acquisition and preprocessing

- The authors have developed an automated algorithm in a preprocessing step to produce high-quality information which improves operational processes



PCD before data processing

X	Y	Z	Rf	Gf	Bf
-16.97142982	149.055542	-1.83205605	1	0.984314	0.694118
-17.40548134	149.3778076	-1.82924902	1	0.980392	0.537255
-17.02037239	149.3696747	-1.83608496	1	0.980392	0.94902
-31.09266853	153.6121979	-1.78347397	1	0.984314	0.156863
-31.22300339	152.2851105	-1.804775	1	0.984314	0.478431
-31.15230179	152.1466675	-1.80657601	1	0.984314	0.521569
-31.14230347	152.2229767	-1.80526304	1	0.984314	0.501961
-31.10012245	152.179596	-1.80596495	1	0.984314	0.439216
-31.11326408	152.1891937	-1.80572104	1	0.984314	0.513725
-31.11257935	152.2046509	-1.80541599	1	0.984314	0.247059
-31.00472069	152.0660858	-1.80657601	1	0.984314	0.321569
-31.05157852	152.0063629	-1.80816305	1	0.984314	0.290196

PCD X, Y and Z coordinates and color intensity (Red, Green, Blue)

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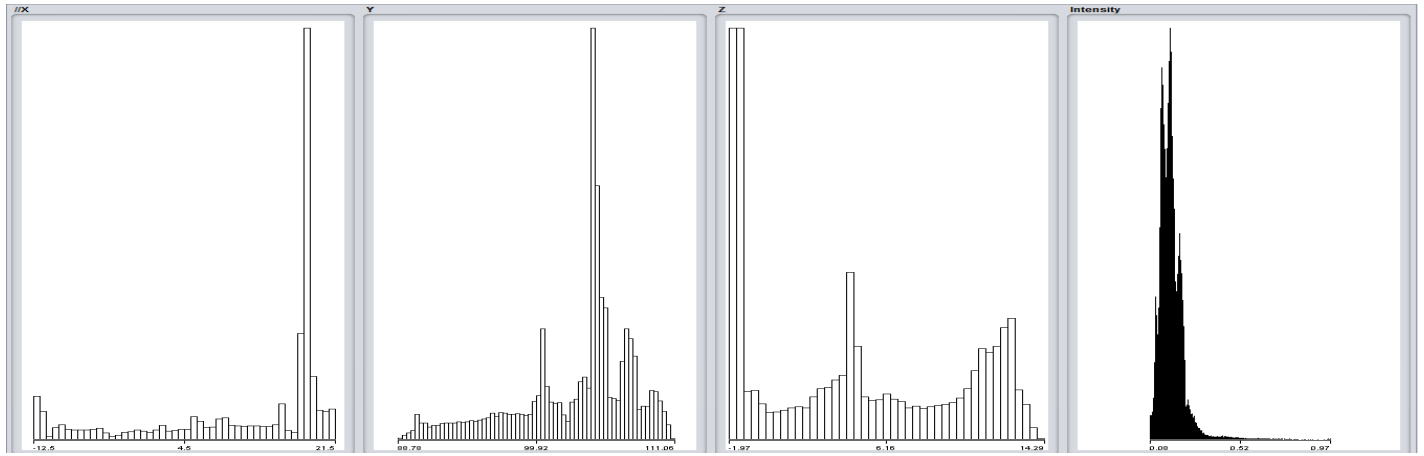
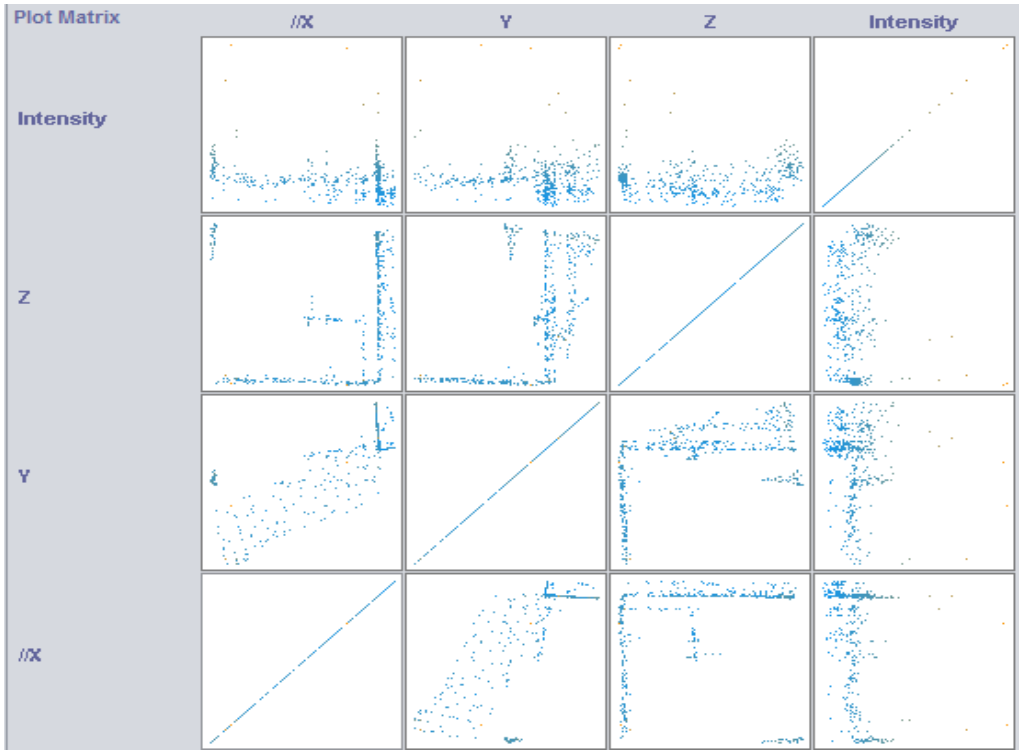
Data acquisition and preprocessing

- In the PCD data, each point contains X, Y, and Z coordinates with its color intensity.
- The distribution of the points along the X, Y, and Z dimensions and the color intensity by individual points shows in the following tables.



PCD error range frequency



PCD plot matrix of the case study

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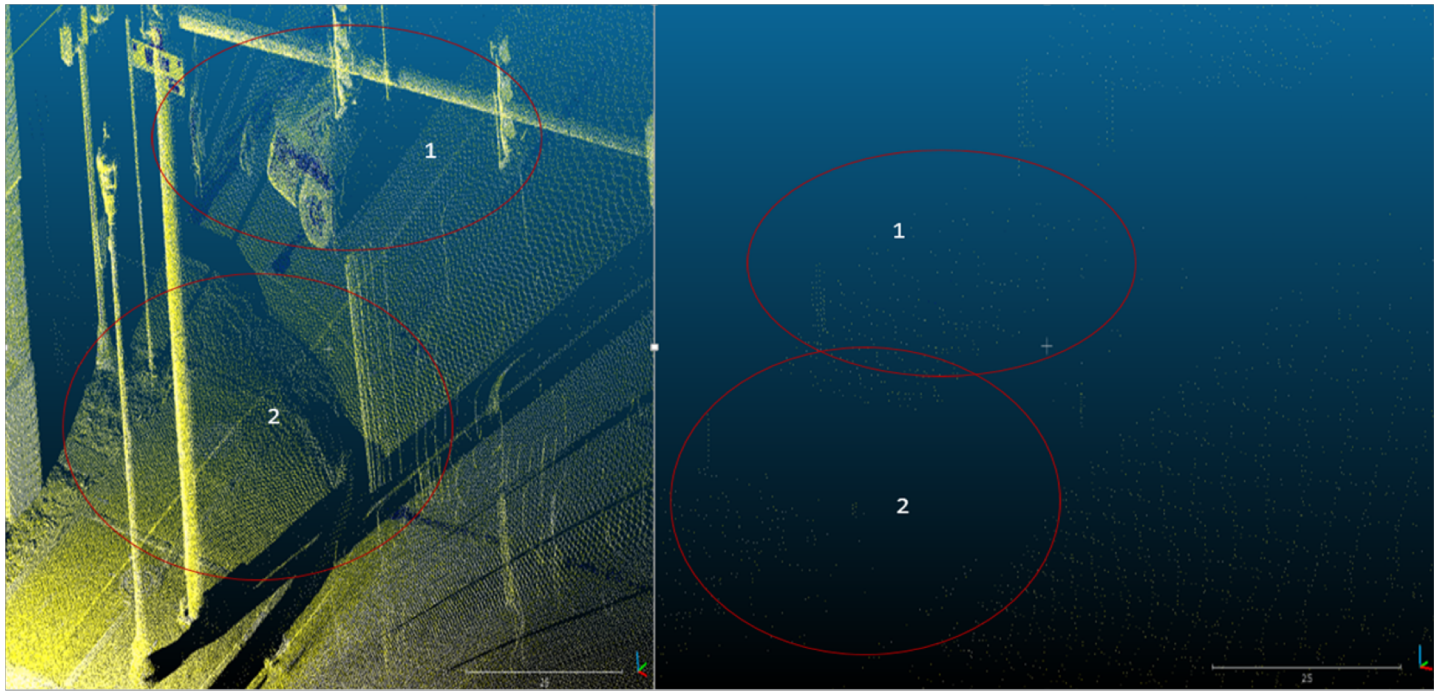
Data processing

- In data processing, elevation and outlier removal filters were applied to the points to exclude the outlier by Descriptive Statistics method (e.g., mean and standard deviation) and to outrange the points based on their coordination information.



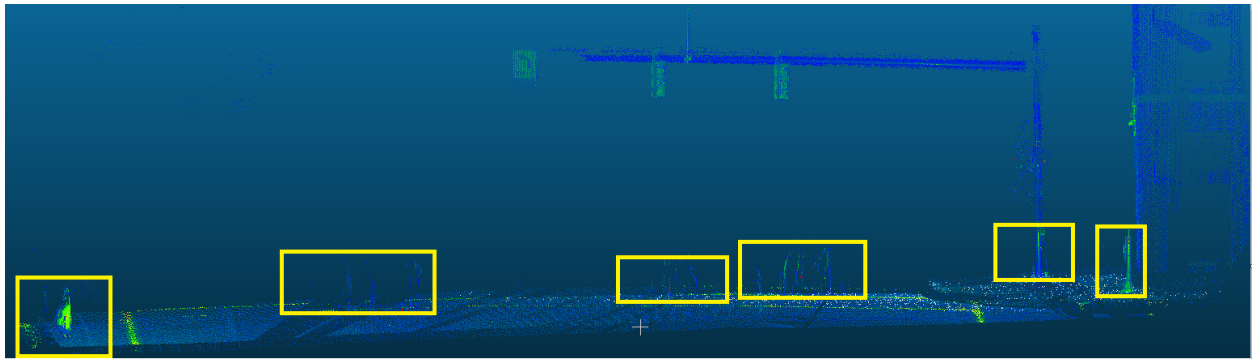
The effect of applied filters on point cloud data

Data processing

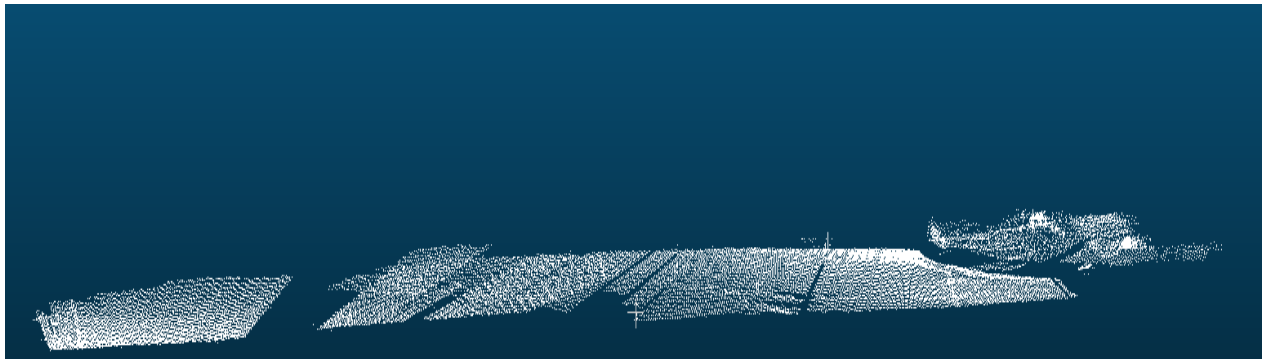
Pass through elevation filter and statistical outlier removal

- Filter the points based on their elevation information
- Conducting descriptive statistics can normalize points in PCD by a variety of statistical methods such as the mean, median, and standard deviation.

Noises and Errors in PCD



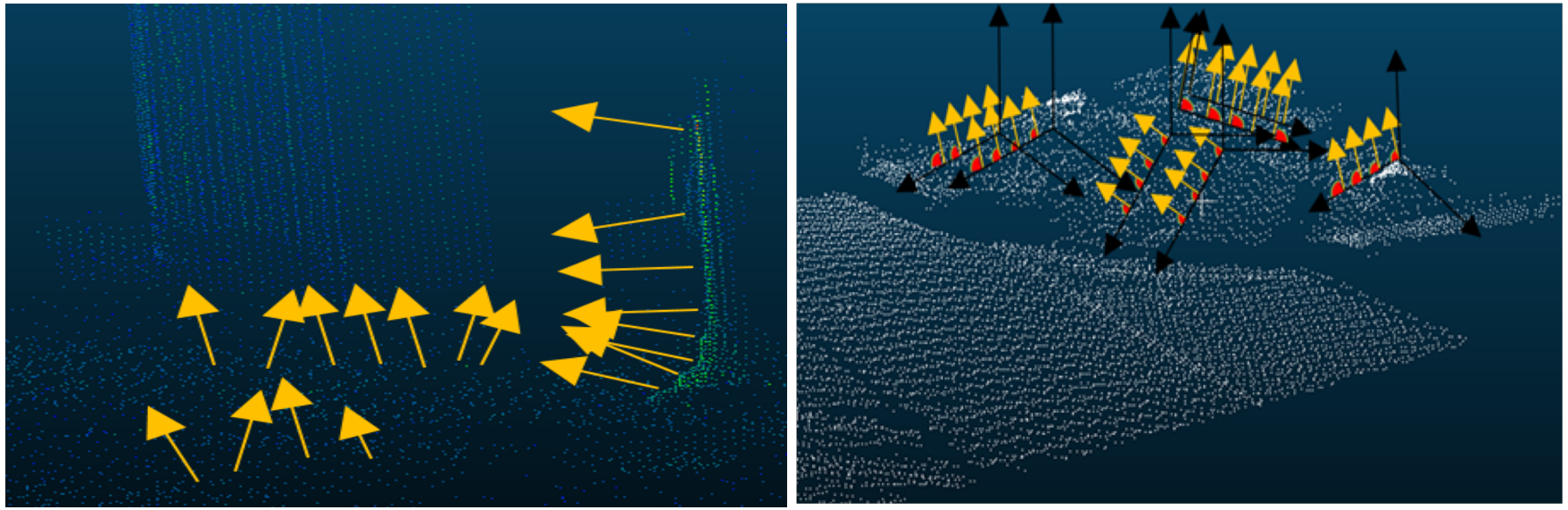
PCD after Pre-Processing



Data processing

Normal estimation

- These steps prepare the PCD for planes/surface fitting.
- Planes/surface fitting is a process where estimated surfaces were fitted with points in the PCD with the angular direction of the surface deviating no more than 15 degrees away from the strict vertical vector.
- Plane is computing the plane equation for the set of data in Euclidean space



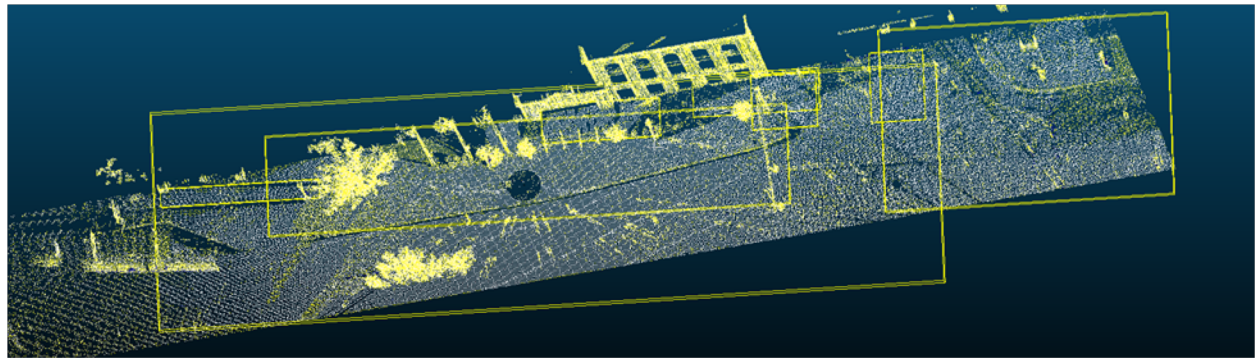
Non-uniform and uniform PCD after normal vector estimation

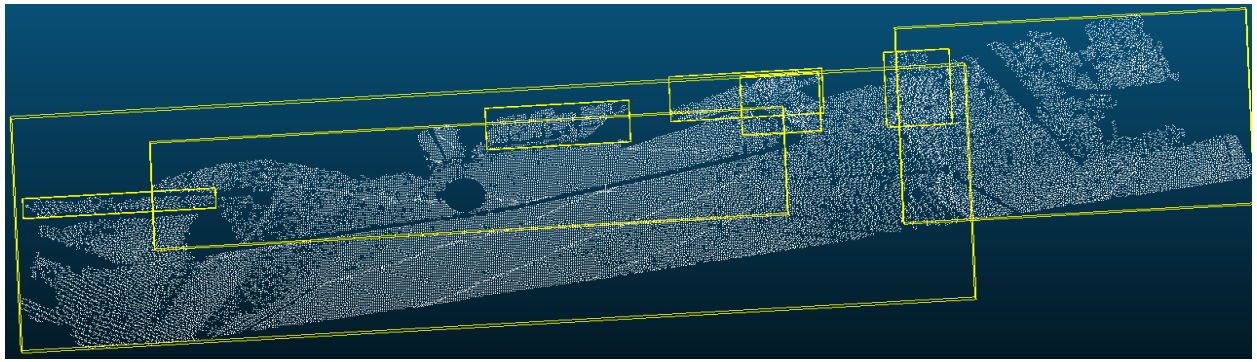
Data processing

Classification

- The boundary points in the automated segmentation provide numerous benefits for road facilities evaluation such as the facility's edge detections.
- In an attempt to improve efficiency and accuracy on our classification step, we develop an automated curb ramp and sidewalk detection method based on the plane vectors.

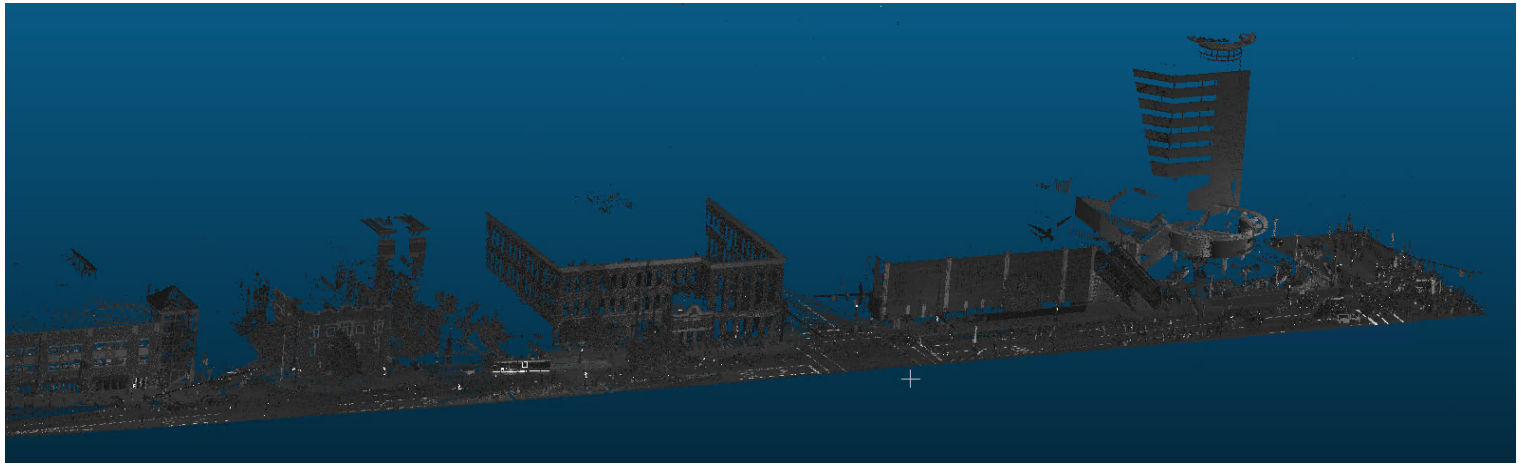
Sidewalk surfaces detected in automated PCD With and without surrounding objects





CASE STUDY

- The case study of this project located on Ross Street between West Michigan Ave. and East Kalamazoo Ave. in downtown Kalamazoo



The Bird-eye-view image of the Case Study area and its PCD

EXPERIMENT and RESULTS

- The experiment was conducted to evaluate the accuracy of the proposed method.
- The mean absolute of the selected curb ramps data is 0.22%, which shows the accuracy of our proposed method. Three out of 5 selected curb ramps passed ADA requirements
- The mean absolute of the selected sidewalk ramp slope is 0.13%

The Curb Ramp's Slope Measuring Results			
Number	By Manual Measurements	By Proposed Method	Difference
1	8.17%	7.99%	0.18%
2	10.42%	10.21%	0.21%
3	10.42%	10.60%	-0.18%
4	7.11%	6.45%	0.66%
5	7.62%	7.64%	-0.02%

Sidewalk Ramp Slope Measuring Results			
Number	By Manual Measurements	By Proposed Method	Difference
1	1.23%	0.95%	0.28%
2	2.00%	1.67%	0.33%
3	1.14%	1.57%	-0.43%

CONCLUSION

- This study is one of the few in using an automated method to assess the compliance of roadway features with ADA.
- An automated ADA assessment method for the roadway is proposed based on PCD data processing.
- The method includes the steps of data acquisition and preprocessing, data processing, classification, and feature extraction.
- Various techniques were utilized such as normal estimation, surface fitting, segmentation, and road feature categorization.
- The results show that the mean absolute standard deviation of the selected curb ramps data is 0.22% and the sidewalks are 0.13% when comparing with other manual measurements

Thank You!

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