

Large-scale Road Characterization Leveraging Mobile Lidar Data

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Introduction

Methodology

Data

Implementation

Results

Evaluation

Conclusion

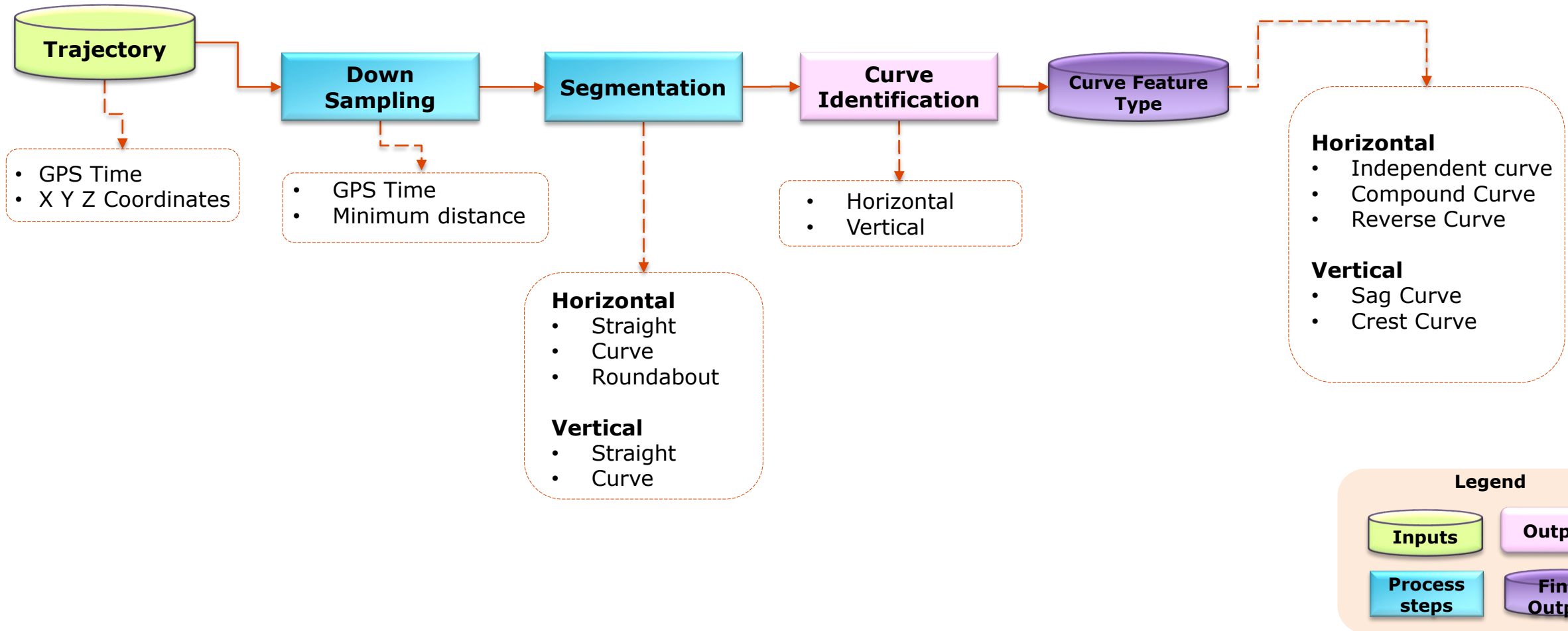
- **Motivations**

- ODOT operates mobile lidar systems to cover statewide highway every two years providing as-built data.
- Various automated tools can be leveraged to substantially improve the efficiency of data processing.

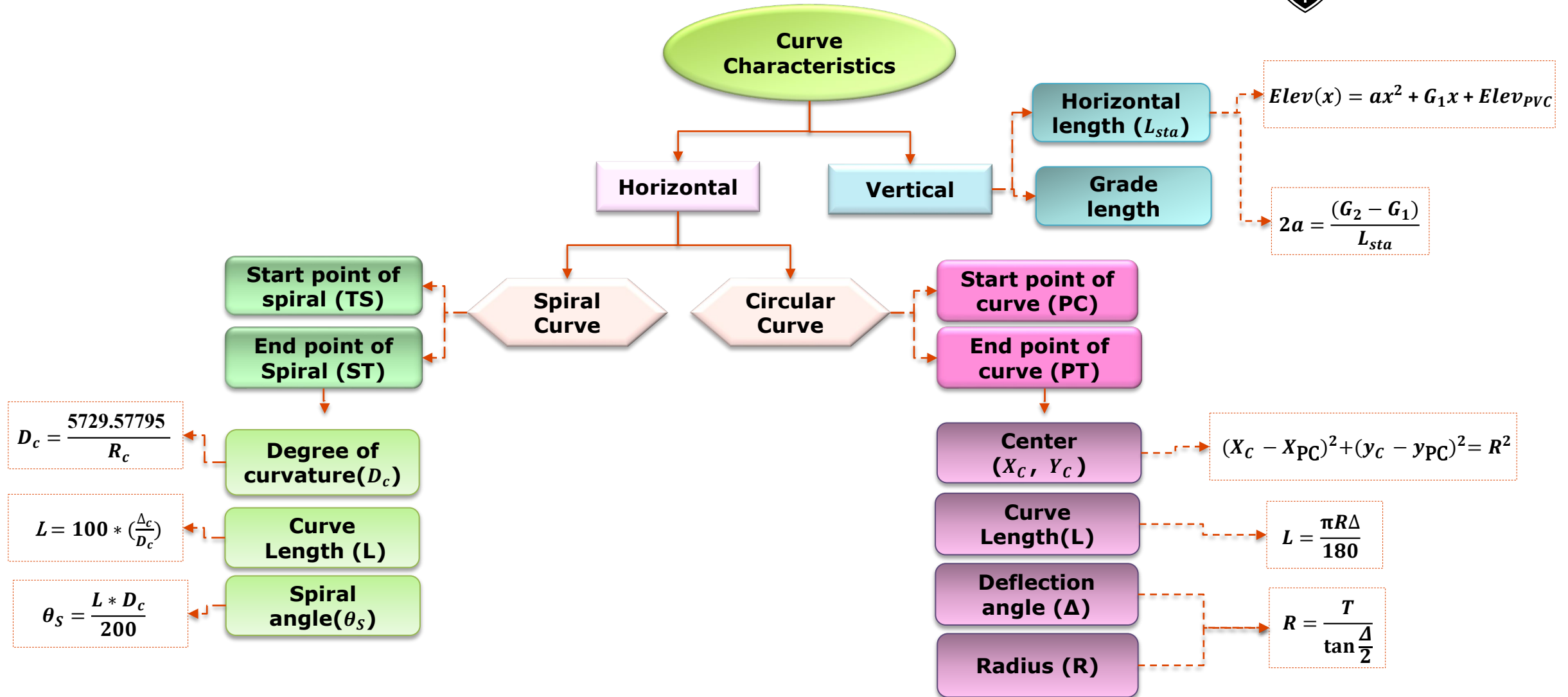
- **Objectives**

- Automatic identification of different curve types in horizontal and vertical direction along road from Mobile Lidar Data
- Automatic extraction of road characteristics from Mobile Lidar Data

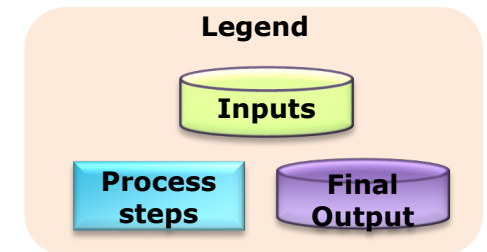
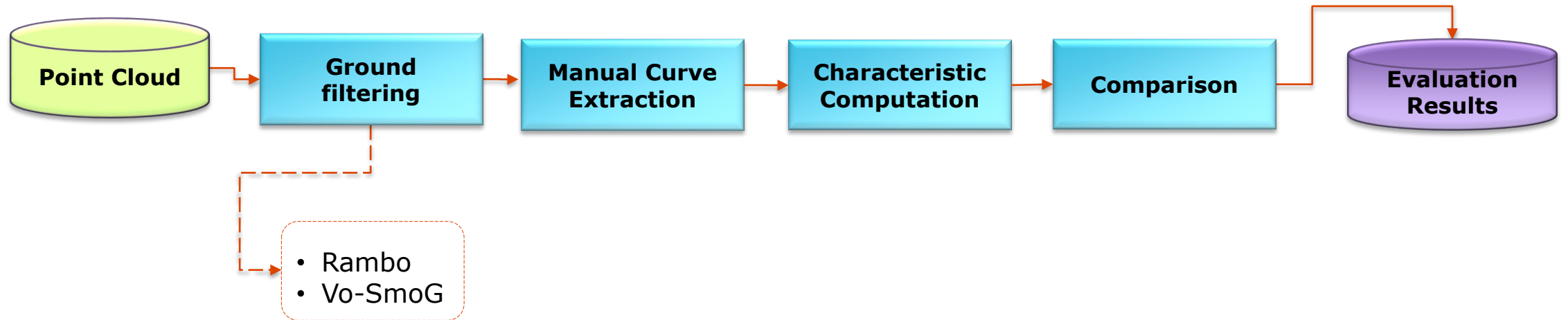
Curve Identification



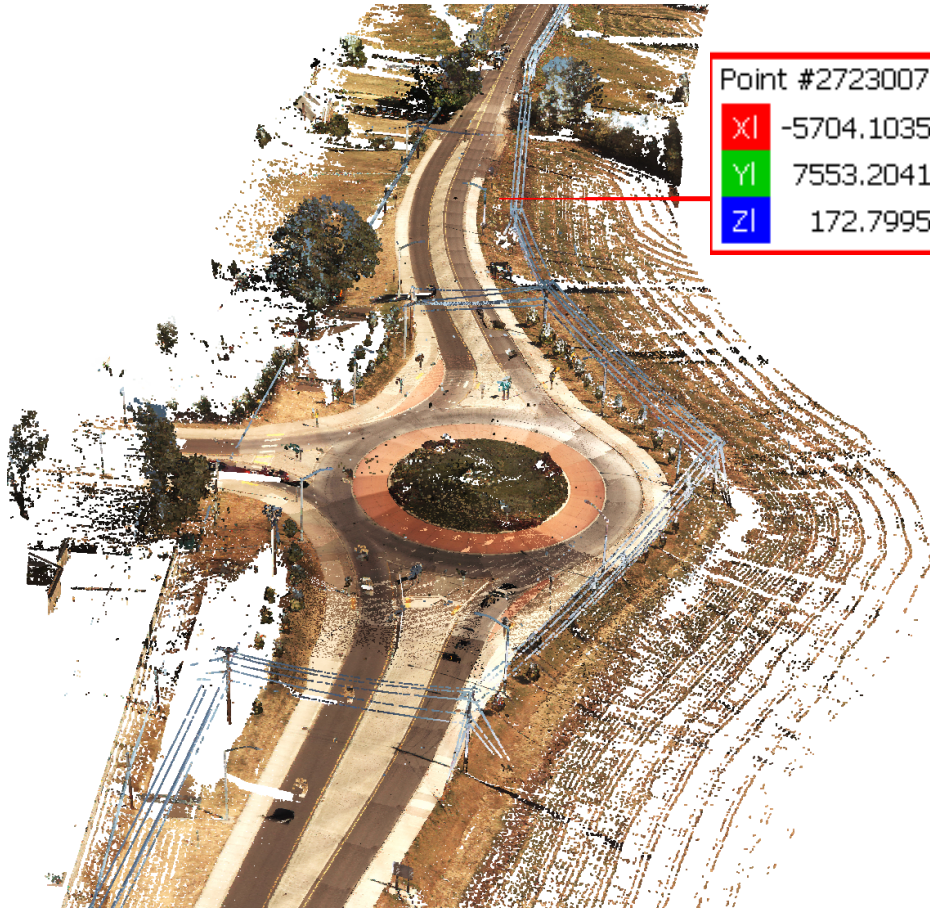
Characterization



Comparison and Evaluation



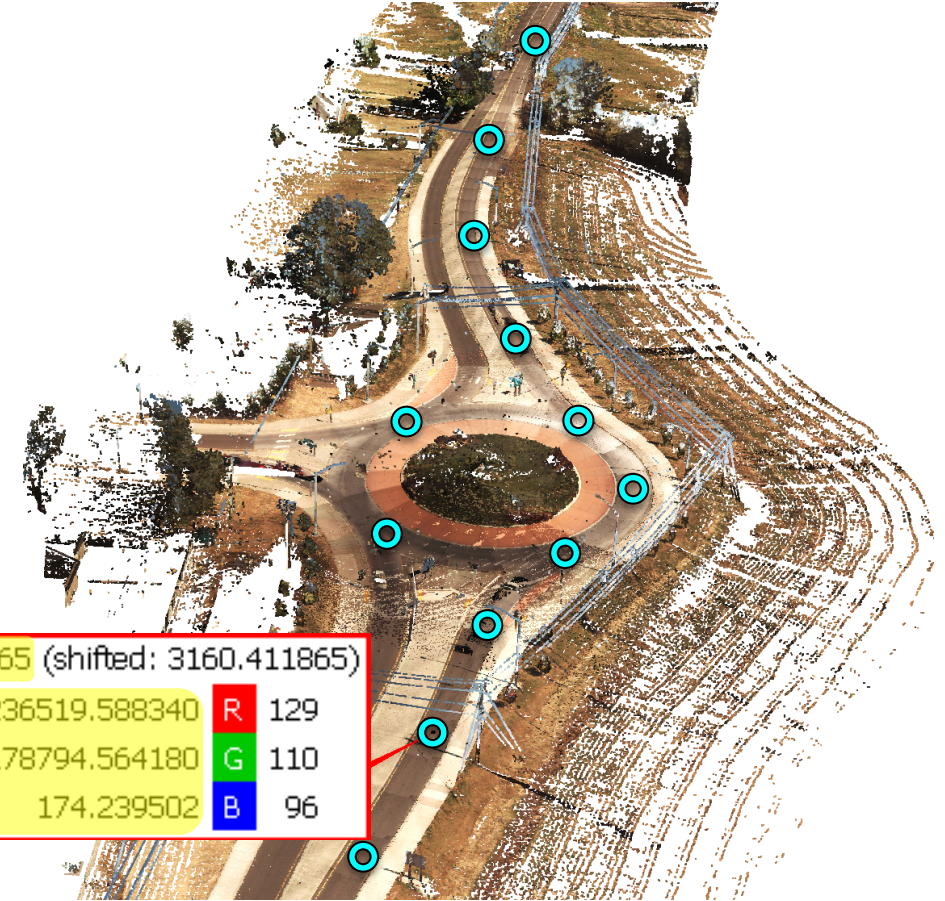
- Point cloud



Point #2723007

Xl	-5704.103516	Xg	236519.186484	R	144
Yl	7553.204102	Yg	178901.484102	G	121
Zl	172.799500	Zg	172.799500	B	105

- Trajectory points



Gps Time = 323160.411865 (shifted: 3160.411865)

Xl	-5703.701660	Xg	236519.588340	R	129
Yl	7446.284180	Yg	178794.564180	G	110
Zl	174.239502	Zg	174.239502	B	96

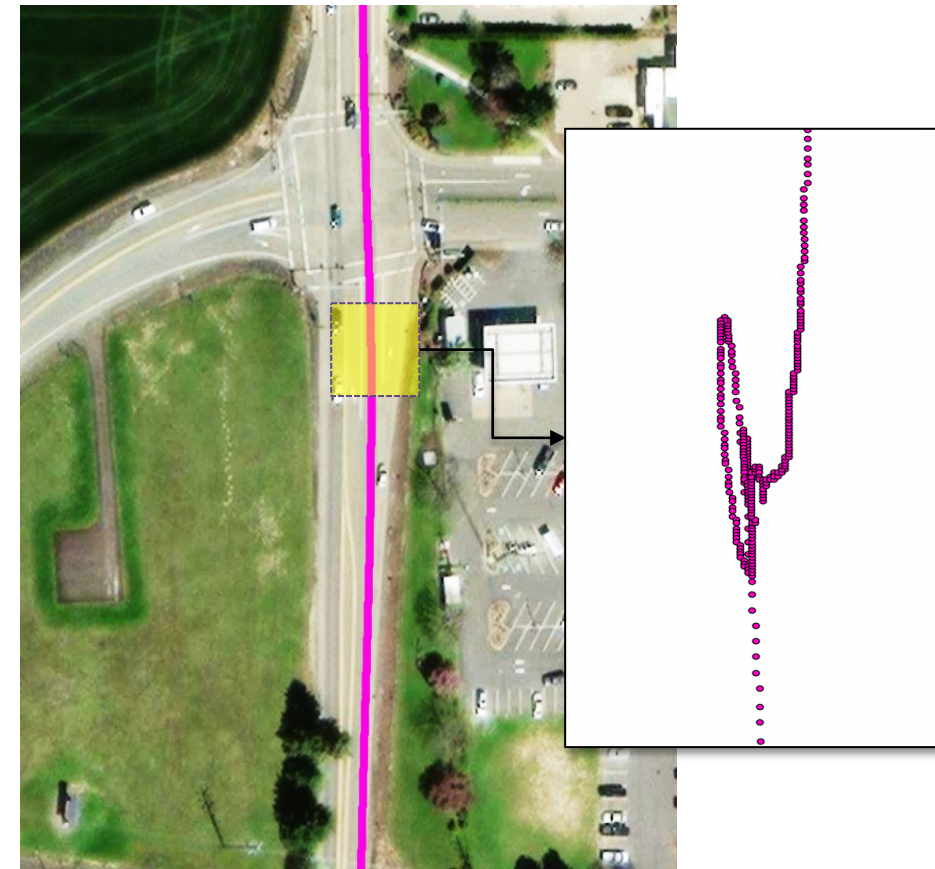
Down Sampling

- Trajectory before down sampling

Roundabout

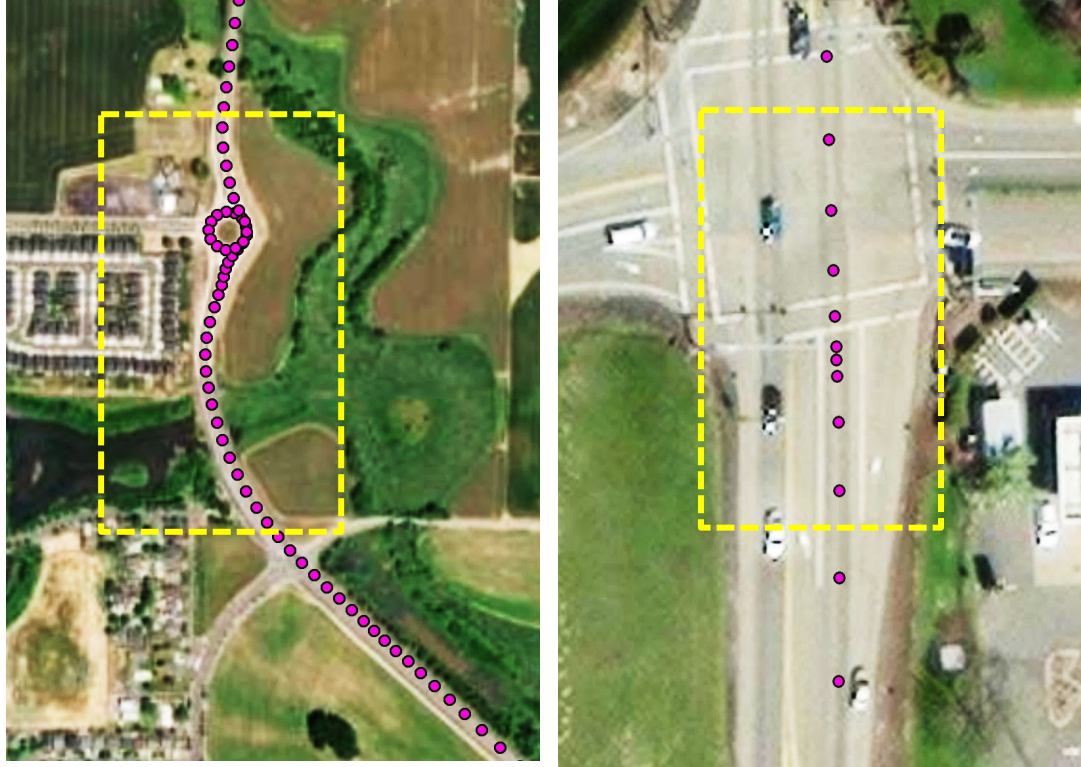


Intersection

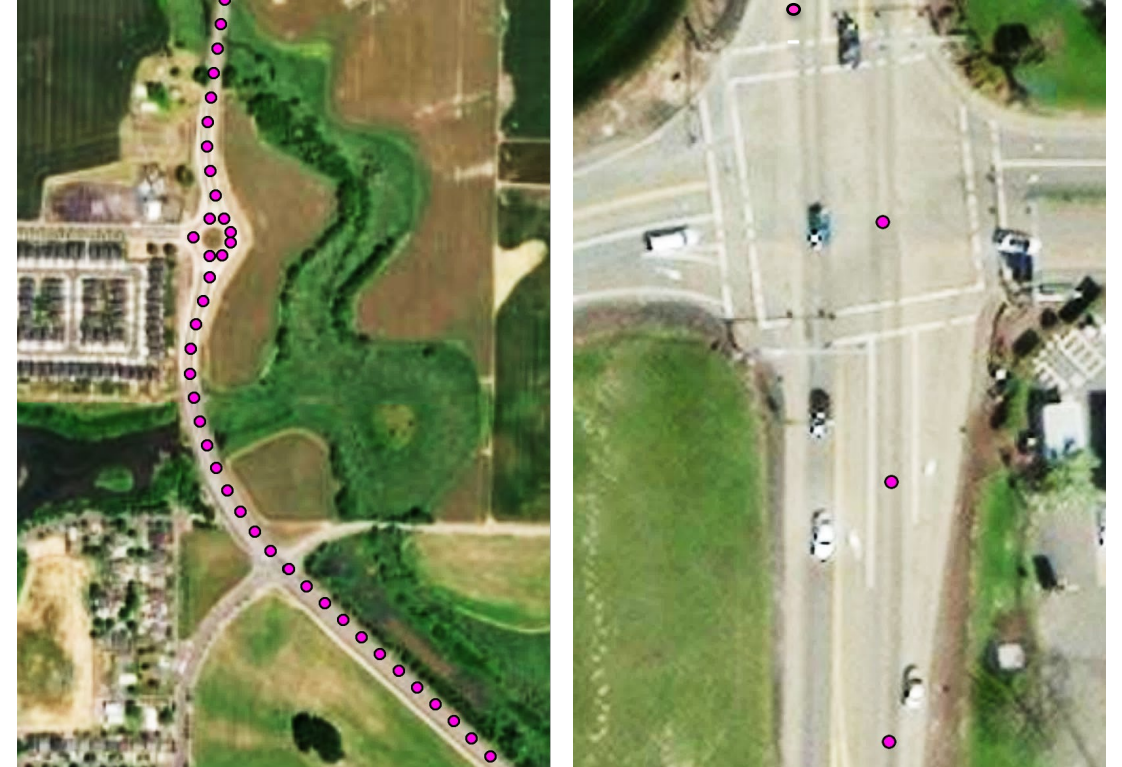


Down Sampling

- GPS time

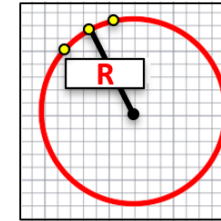


- GPS time and minimum distance

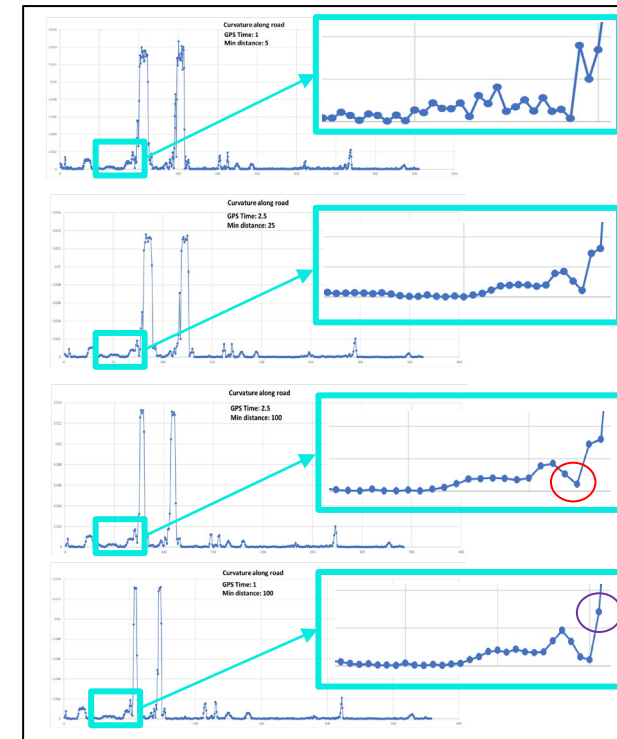


Horizontal Segmentation

1. Fitting circle to each point with least square
2. Calculation of curvature of circles
3. Analyzing curvature and setting threshold

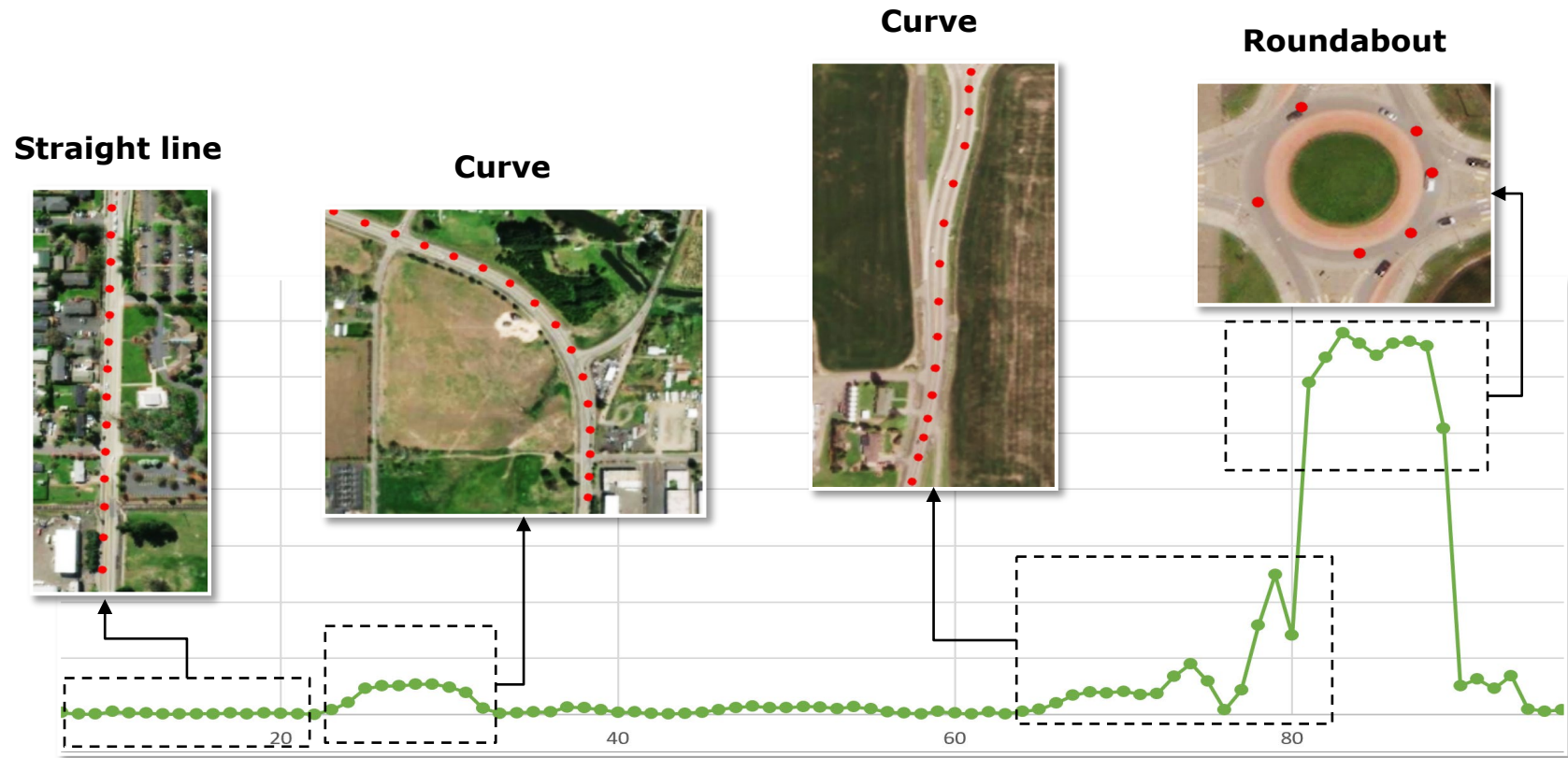


$$\text{Curvature} = \frac{1}{R}$$



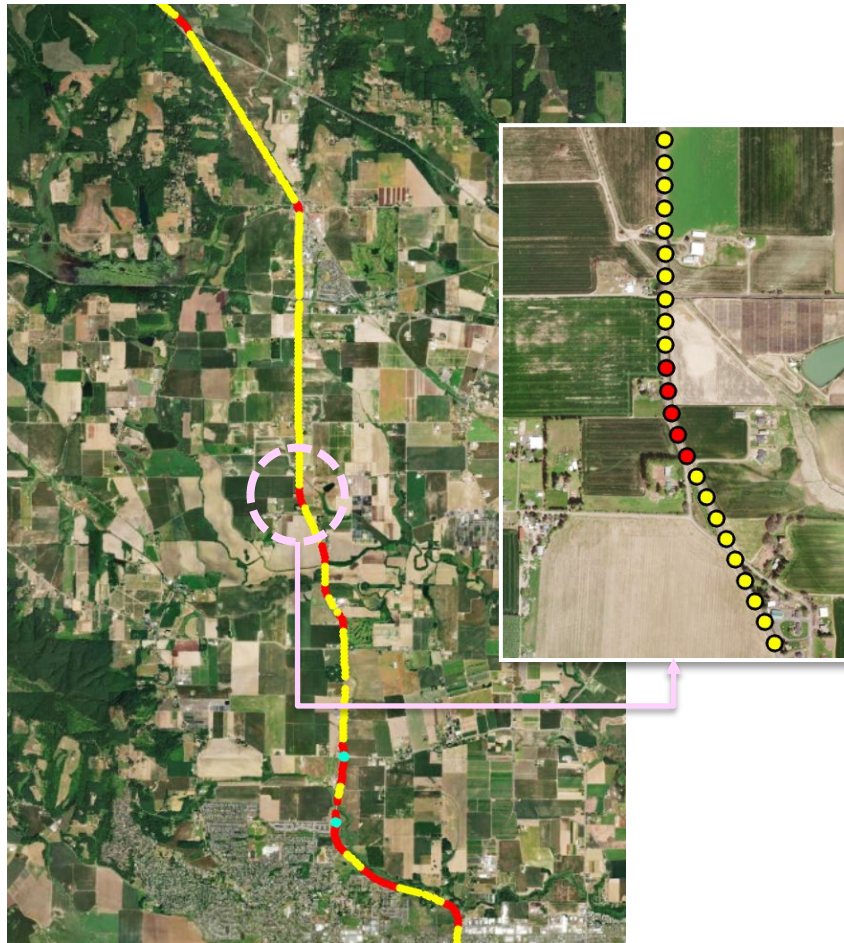
Horizontal Segments

- Straight line
- Curve
- Roundabout

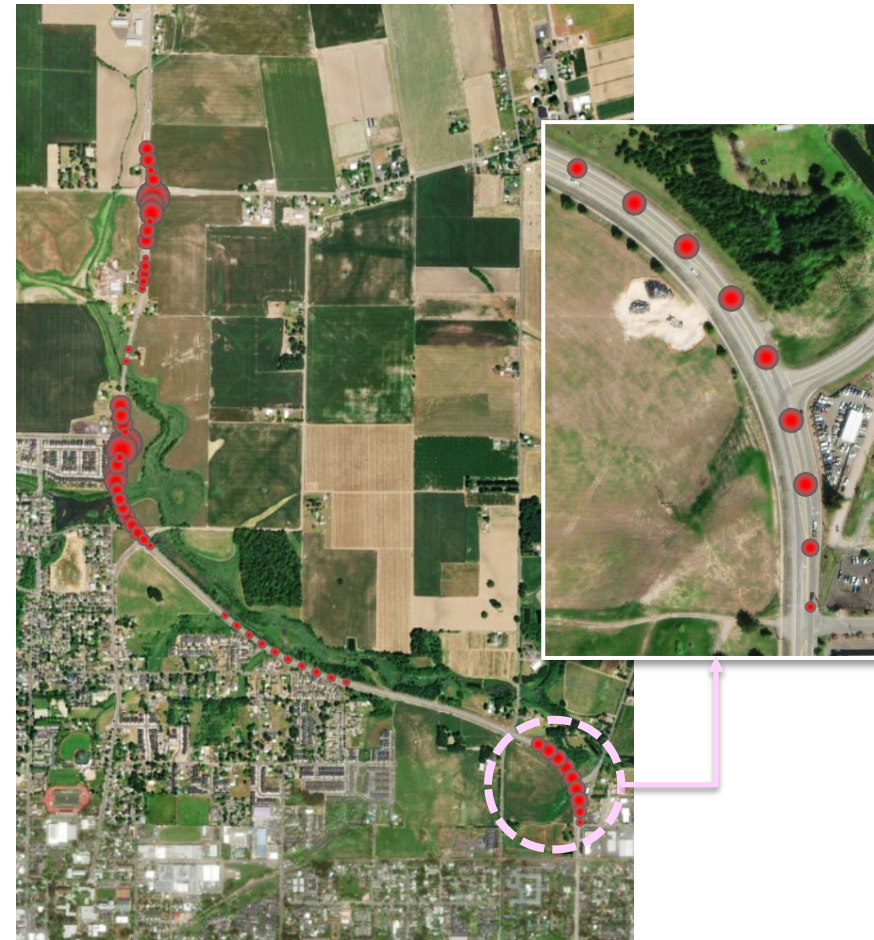


Horizontal Curve Identification

- Horizontal curves



- Curvature change along horizontal curves



Legend

- curve
- Straight
- Curvature

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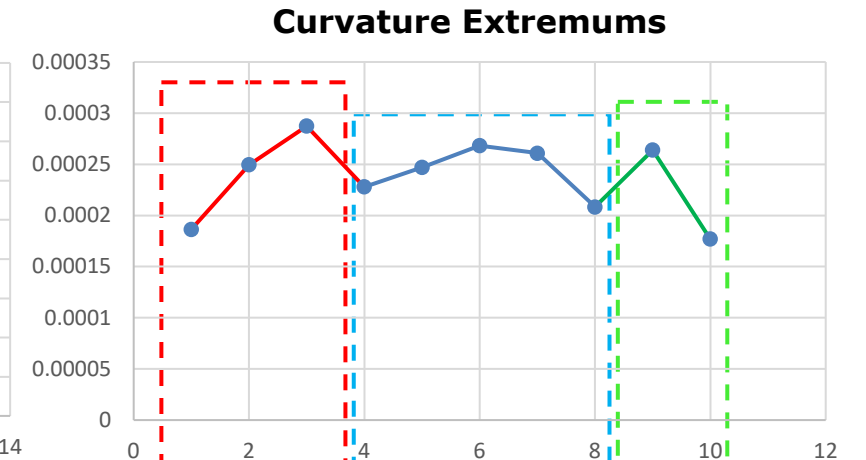
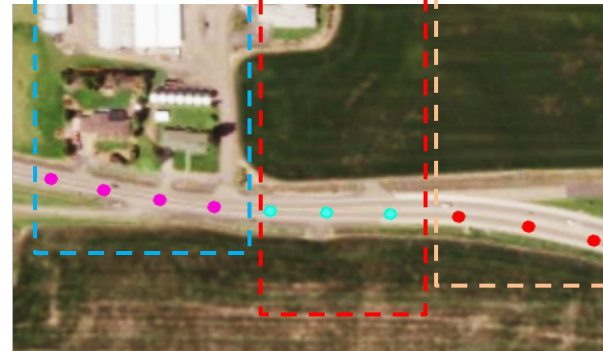
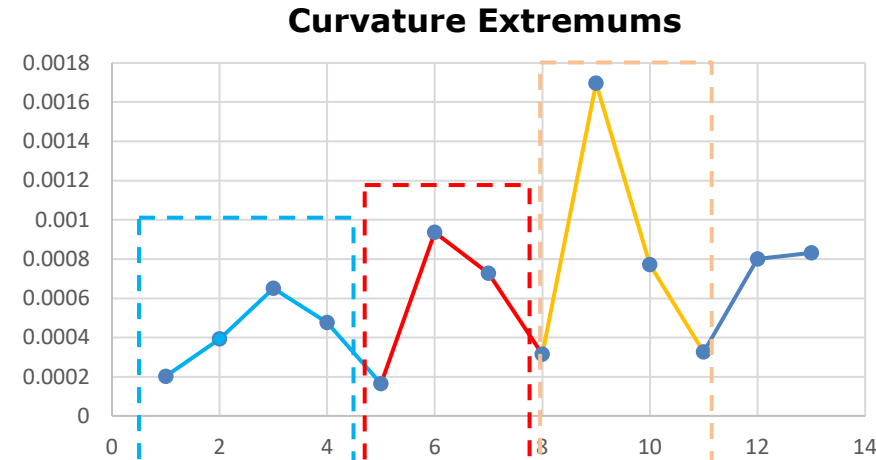
Results

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Horizontal Curve Feature Type

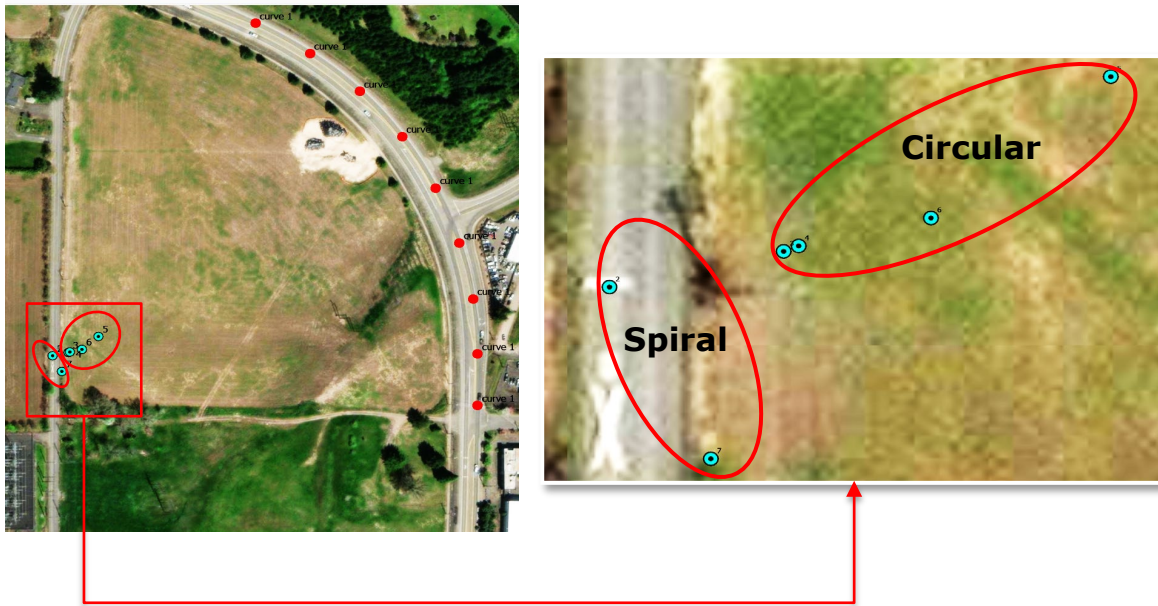
- Reverse Curve
- Compound Curve



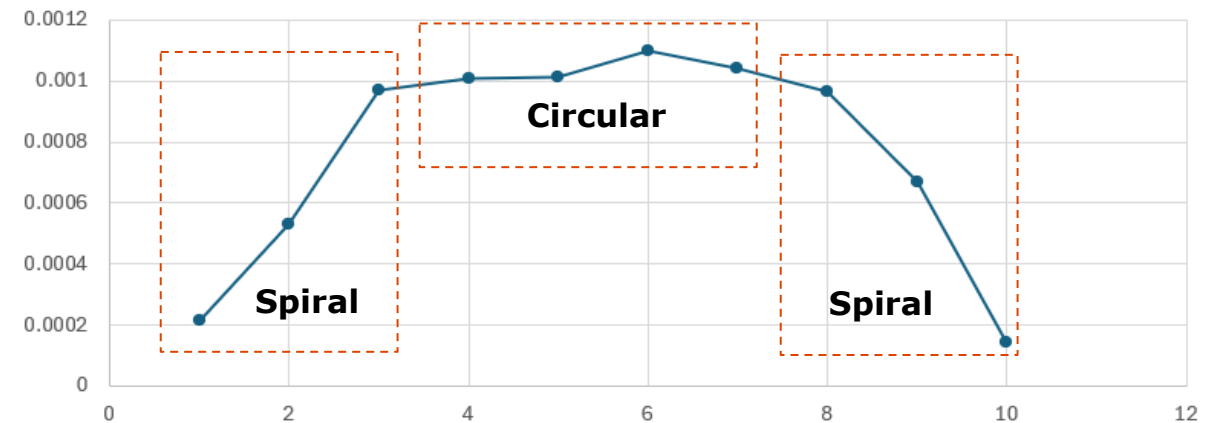
Horizontal Curve Feature Type

- Independent curve with presence of spiral

Centers distances



Curvature changes



Vertical Segmentation

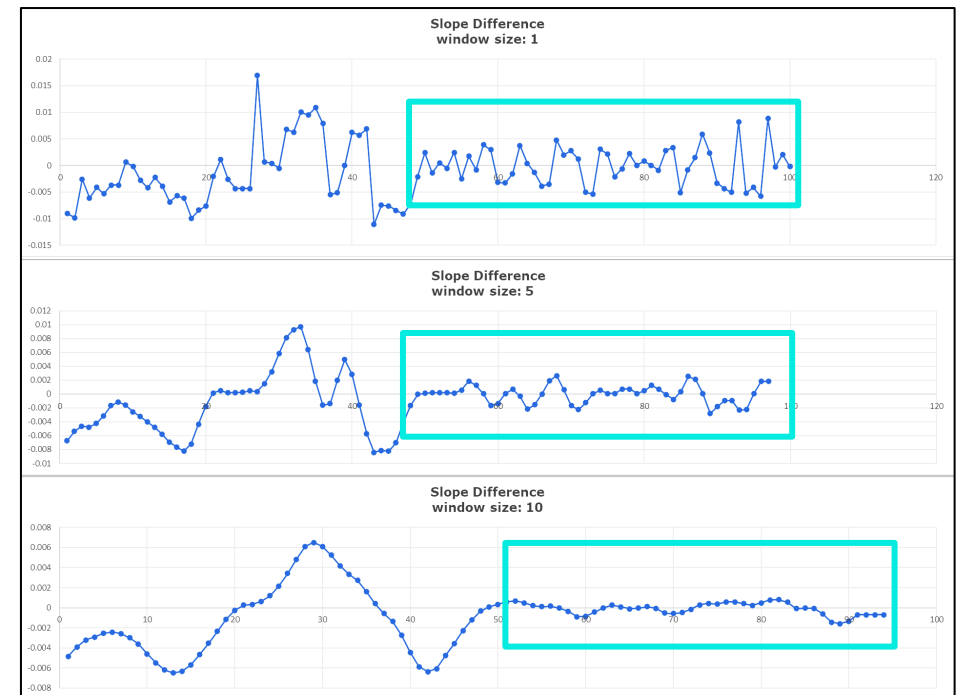
1. Calculation of slope

$$\text{Slope} = \frac{dz}{\sqrt{(dx)^2 + (dy)^2}}$$

2. Smoothing slope changes

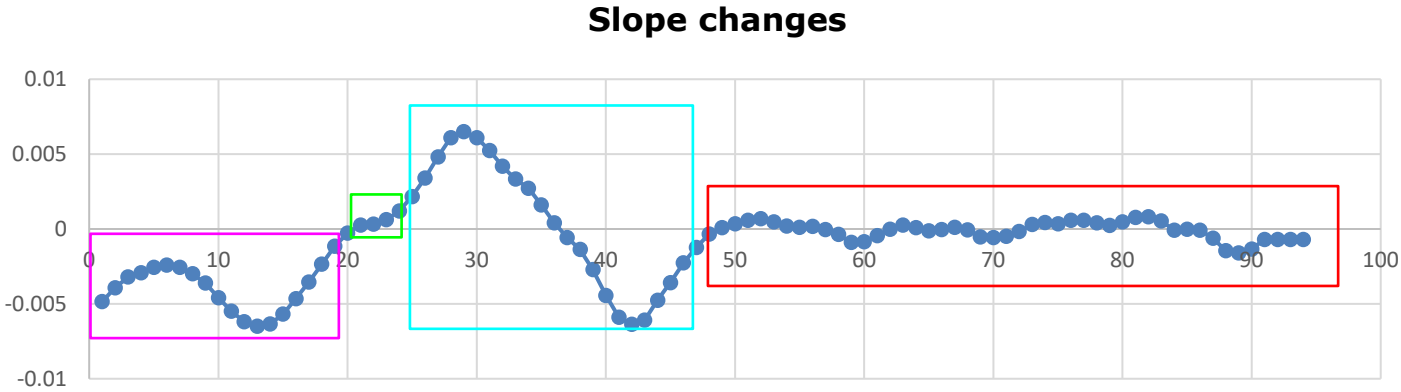
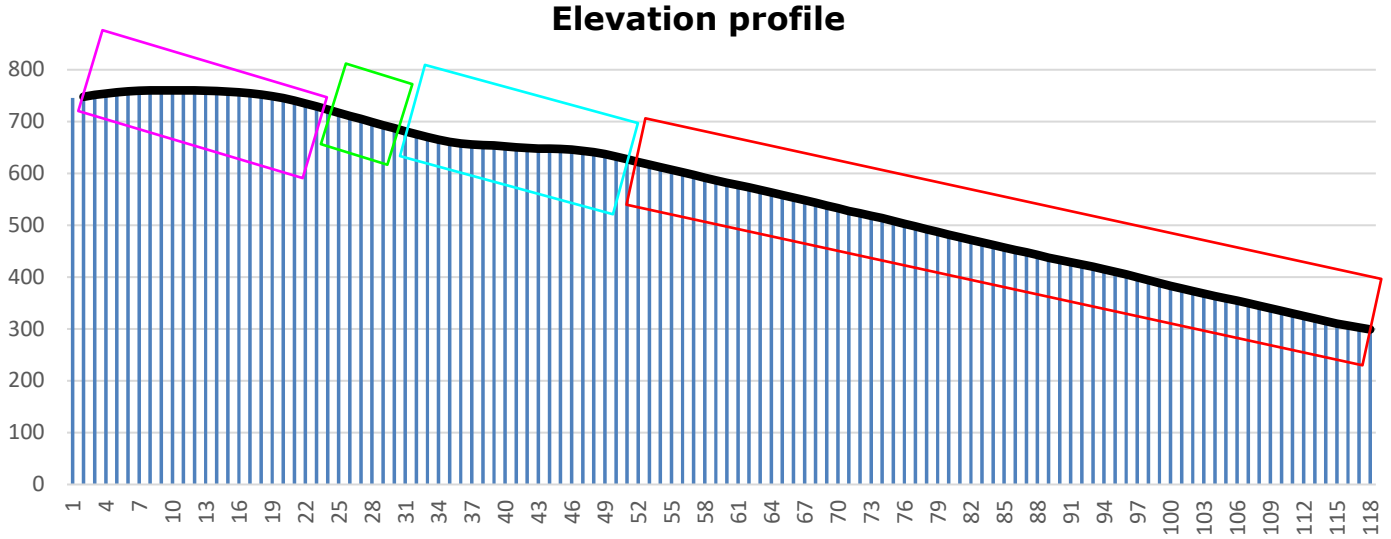
Moving window

3. Analyzing slope changes and Setting threshold



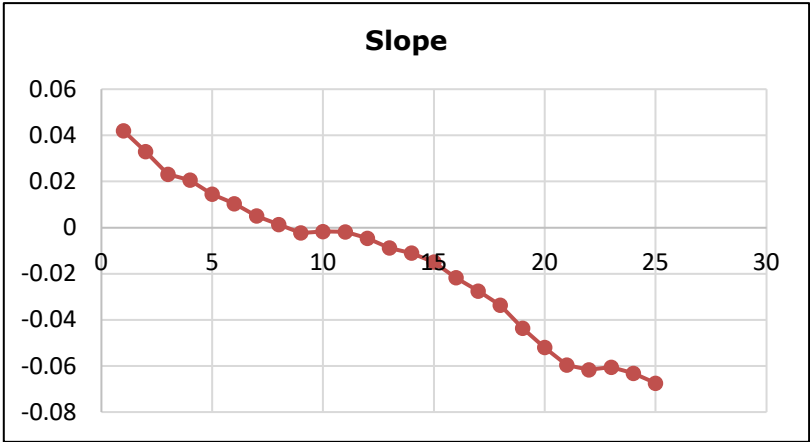
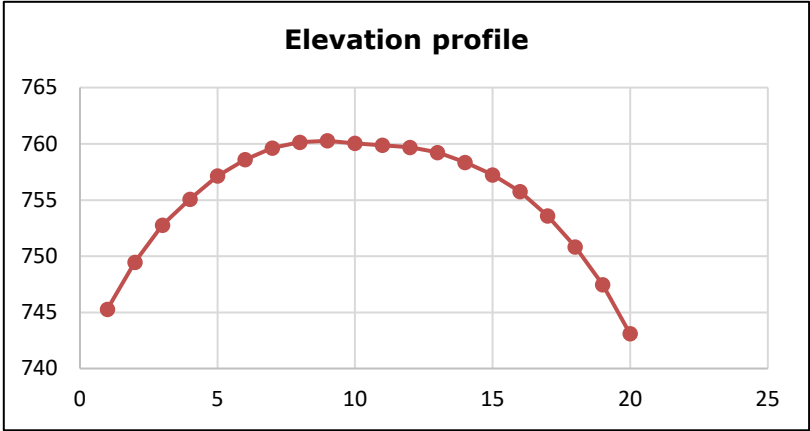
Vertical Segments

- Straight line
- Curve

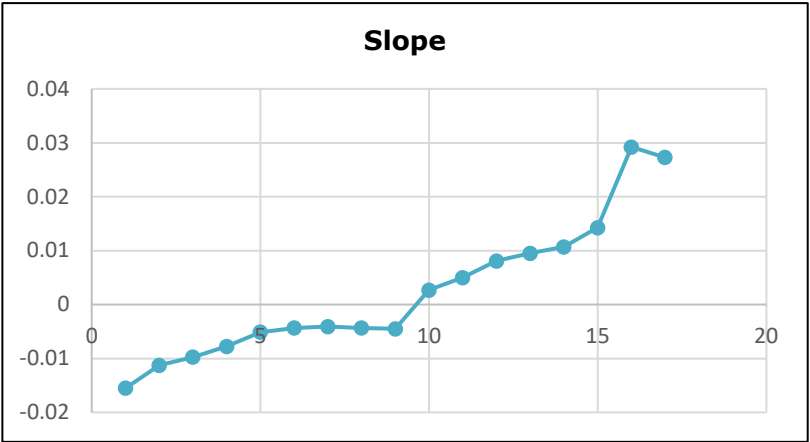
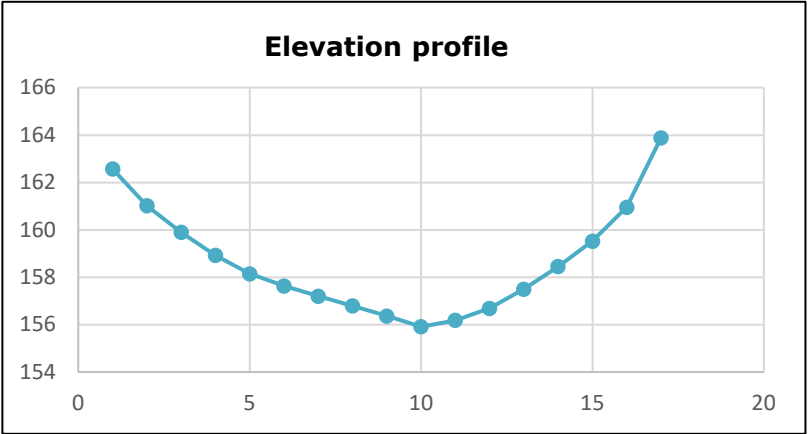


Vertical Curve Feature Type

- Crest Curve



- Sag Curve



Horizontal and Vertical Road Characteristics

○ Horizontal Circular Curve Characteristics

Curves	SC		CS		Curve Center		Deflection angle (degree)	Radius (feet)	Curve Length (feet)
	X	Y	X	Y	X	Y			
Circular 1	242434.93	173863.73	242194.5	174267.05	241538.35	173602.65	29.13	933.81	474.61
Circular 2	239443.49	175270.44	238867.70	175485.46	240424.19	178775.10	9.69	3639.28	615.36
Circular 3	238867.70	175485.46	238183.89	175892.10	240472.84	178962.92	11.92	3830.04	797.01

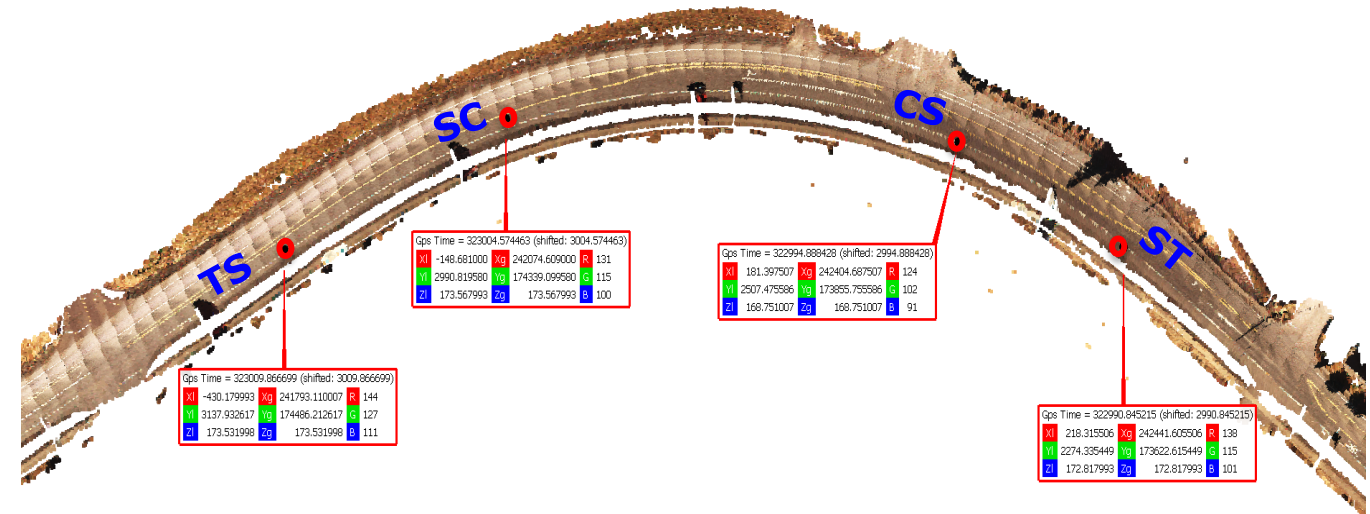
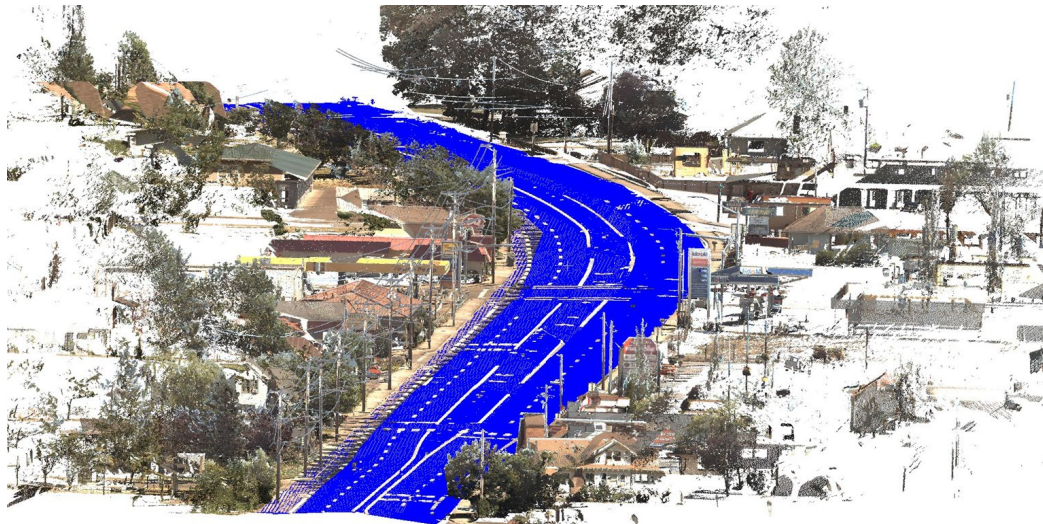
○ Vertical Curve Characteristics

Curves	PVC			PVT			Curve Length (feet)
	X	Y	Z	X	Y	Z	
Curve 1	332490.50	167263.28	745.27	330397.57	167245.39	731.94	900.12
Curve 2	329919.11	167098.26	701.75	328983.23	166310.77	651.07	402.27
Curve 3	328914.30	166122.67	648.12	328327.61	165332.19	619.49	550.03

○ Horizontal Spiral Curve Characteristics

Curves	TS		ST		Degree of curvature (degree)	Curve Length (feet)	Spiral Angle
	X	Y	X	Y			
Spiral 1-S	173431.72	184.01	174514.48	180.12	6.13	585.51	18.02
Spiral 1-E						664.61	20.38
Spiral 2-S	236928.31	181947.05	236882.75	182382.30	5.86	150.55	4.41
Spiral 2-E						141.12	4.13
Spiral 3-S	236940.12	188015.91	236754.05	188576.57	8.88	193.33	8.58
Spiral 3-E						163.05	7.24

- Road extraction from point cloud with Vo-SmoG ground filter
- Manual curve identification in road surface
- Using manual extracted curve points as input for characteristics computations



Contributions

- Horizontal and vertical curve identification automatically
- Extraction of horizontal and vertical characteristics automatically
- The results can be imported and further analyzed as a GIS geodatabase

Limitations and challenges

- Noise and bias in trajectory caused by driving conditions
- Segmentation is sensitive to thresholds

Future works

- Using both road alignments and trajectory
- Train a machine learning model to learn the optimal threshold

Thank You for Your Attention

Special thanks to:

Oregon Department of Transportation (ODOT)

