

RWR 4013

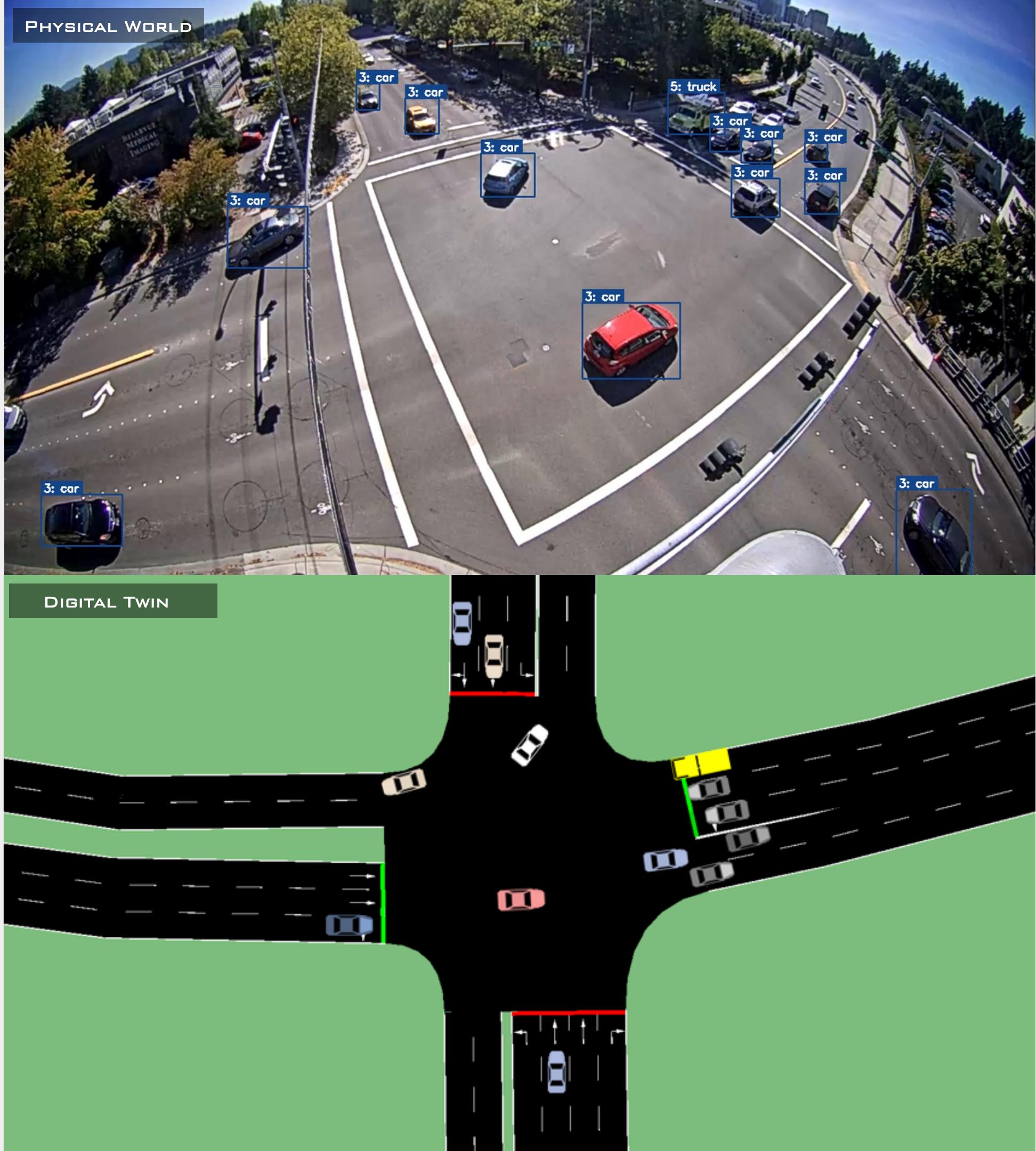
Digital Twins for Smart Cities

Dr. Ahmad Mohammadi

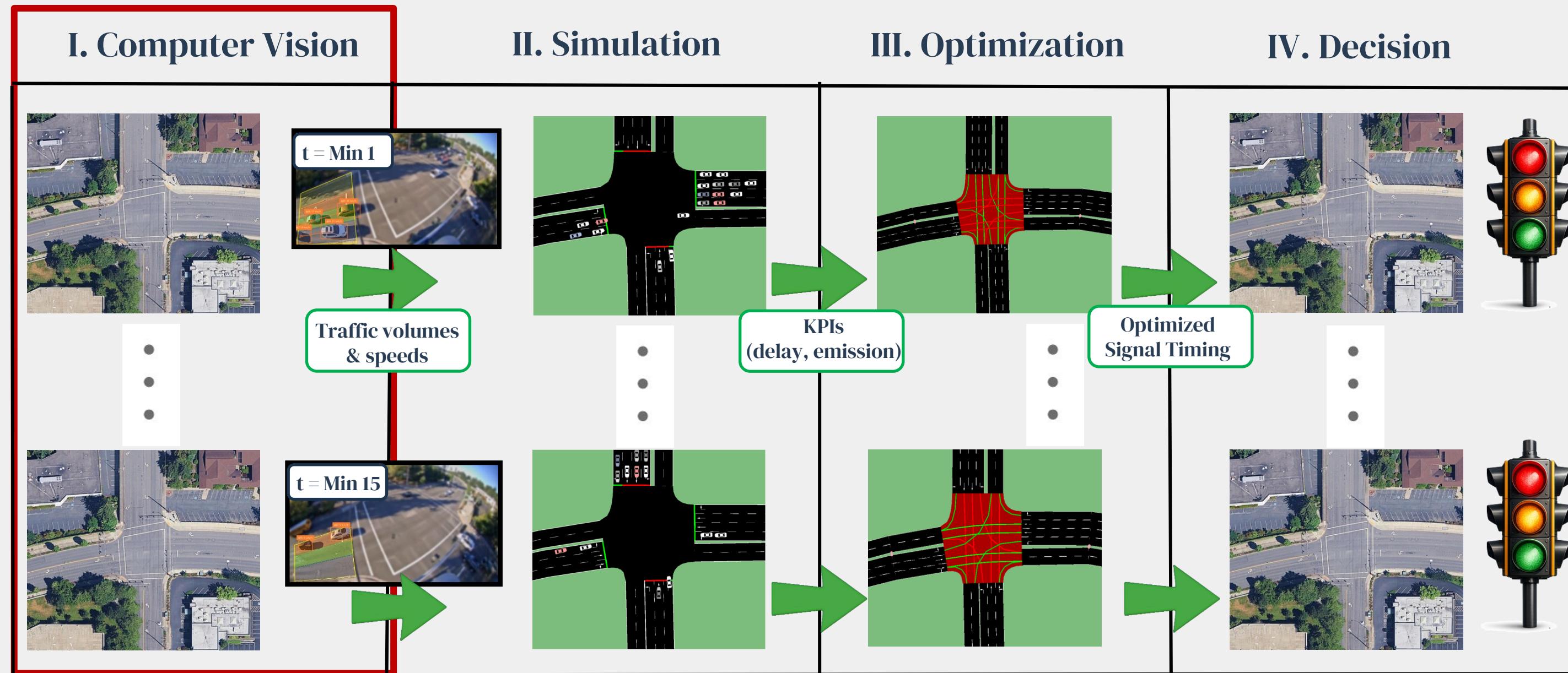
Week 3 | Session 2:
Computer Vision II
(Object Tracking)

Fall 2026

RoadwayVR

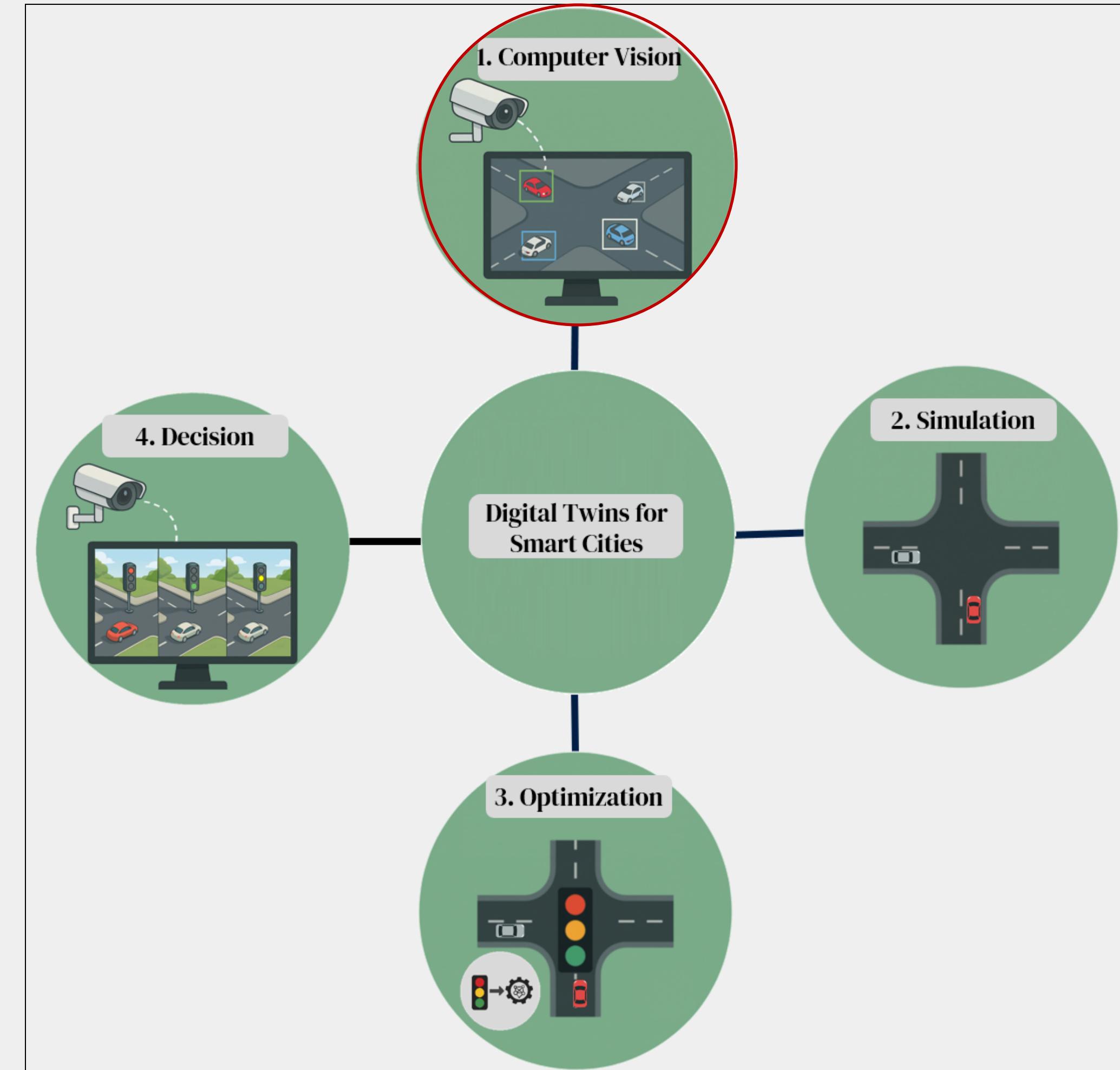


Overview of Course Syllabus in One Shot



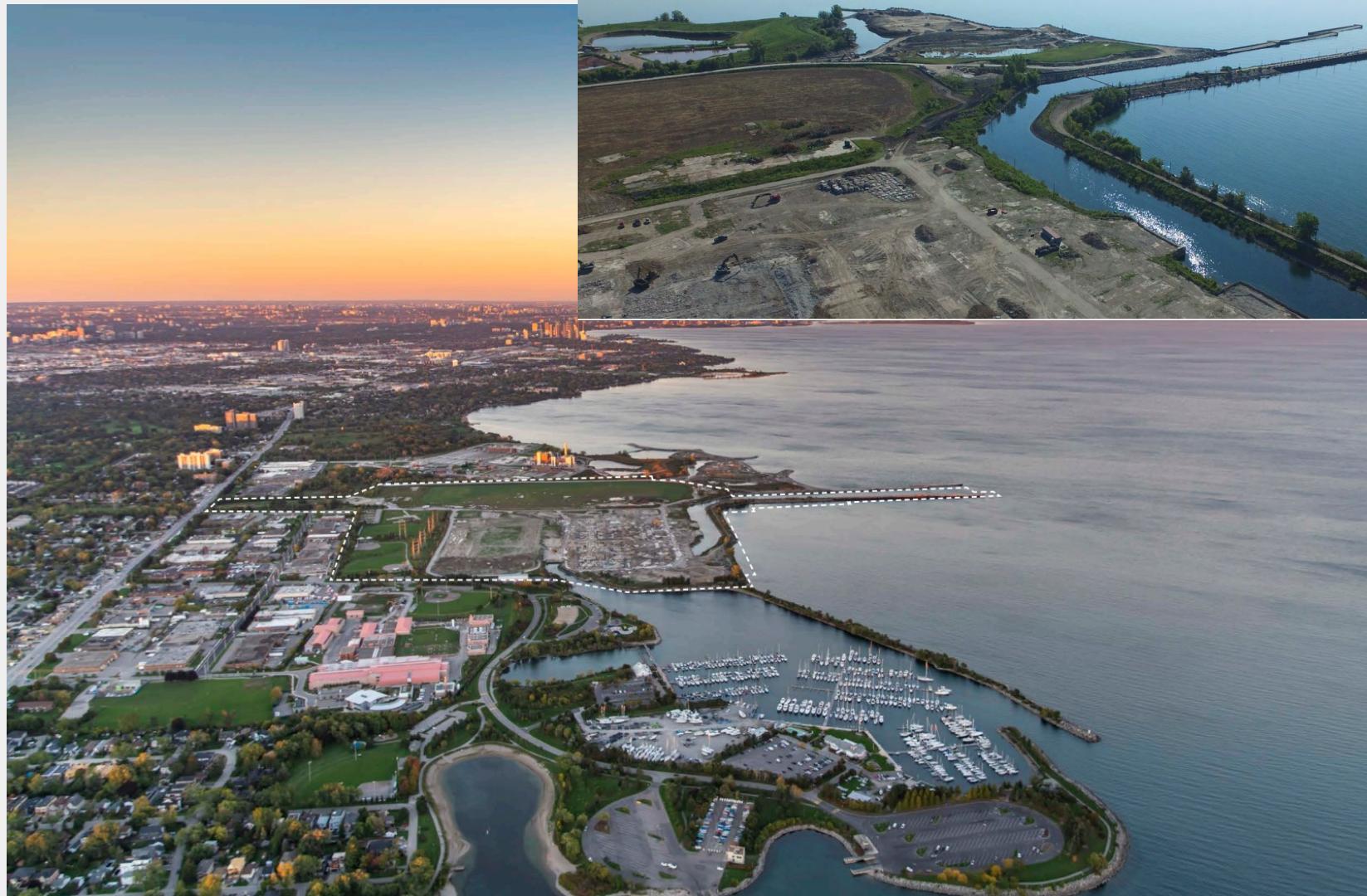
Agenda

- ❑ Real-world Data Collection to Support Planning
Projects
 - ❑ Lakeview Village Redevelopment Project
 - ❑ Example of Observed Traffic Counts
 - ❑ Traffic Movement and Traffic Movement Table
 - ❑ Object Detection and Tracking Using SimJamCV



Real-world Data Collection to Support Planning Projects

Lakeview Village Redevelopment Project (Mississauga, Ontario)



<https://www.mississauga.ca/wp-content/uploads/2018/10/03165546/inspiration-lakeview-masterplan-compressed-2.pdf>

<https://www7.mississauga.ca/Departments/Marketing/documents/building-planning/1082-Lakeshore/VISSIM-Microsimulation-Traffic-Report.pdf>

Lakeview Village

Project goal:

- To evaluate future traffic performance and identify potential intersection queues and delays.

Study Location:

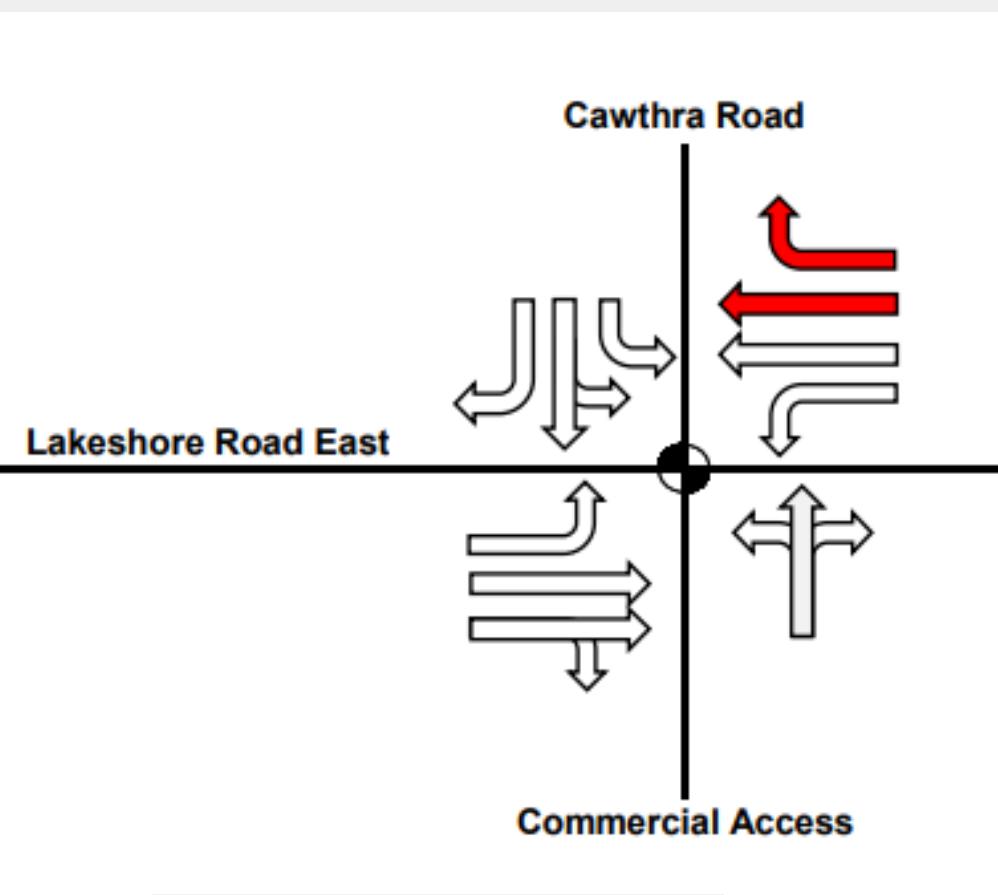
- City/Area:** Mississauga, Ontario (Lakeview waterfront area)

Scenarios:

- Today / Existing: 2016 conditions (**based on observed traffic counts**)
- Future: 2031 (future development)



Traffic Movement



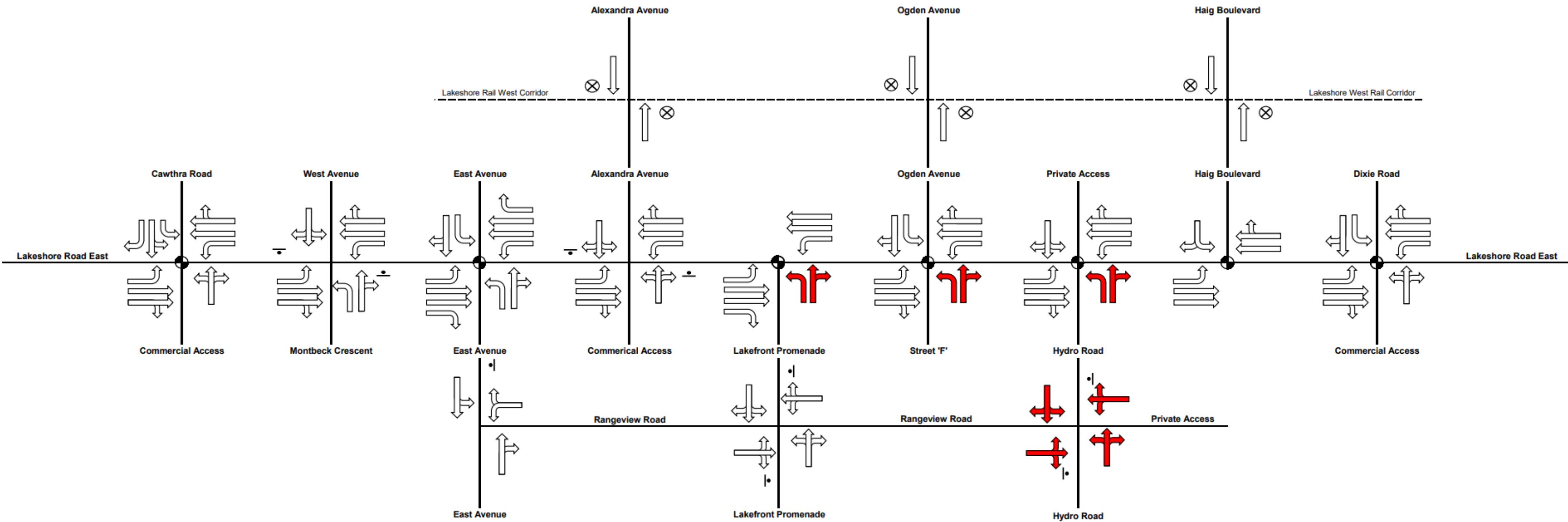
Traffic Movement Table

Intersection	Movement of Interest	Input Volume
Cawthra Road & Lakeshore Road East	EBL	482
	EBT	1072
	EBR	0
	WBL	3
	WBT	695
	WBR	172
	NBL	0
	NBT	0
	NBR	0
	SBL	238
	SBT	2
	SBR	379

Example of Observed Traffic Counts



Traffic Movement



LEGEND

- Existing Lane
- New/Modified Lane
- Signalized Intersection
- Stop Control
- Railroad Crossing



Traffic Movement Tables for All Intersections

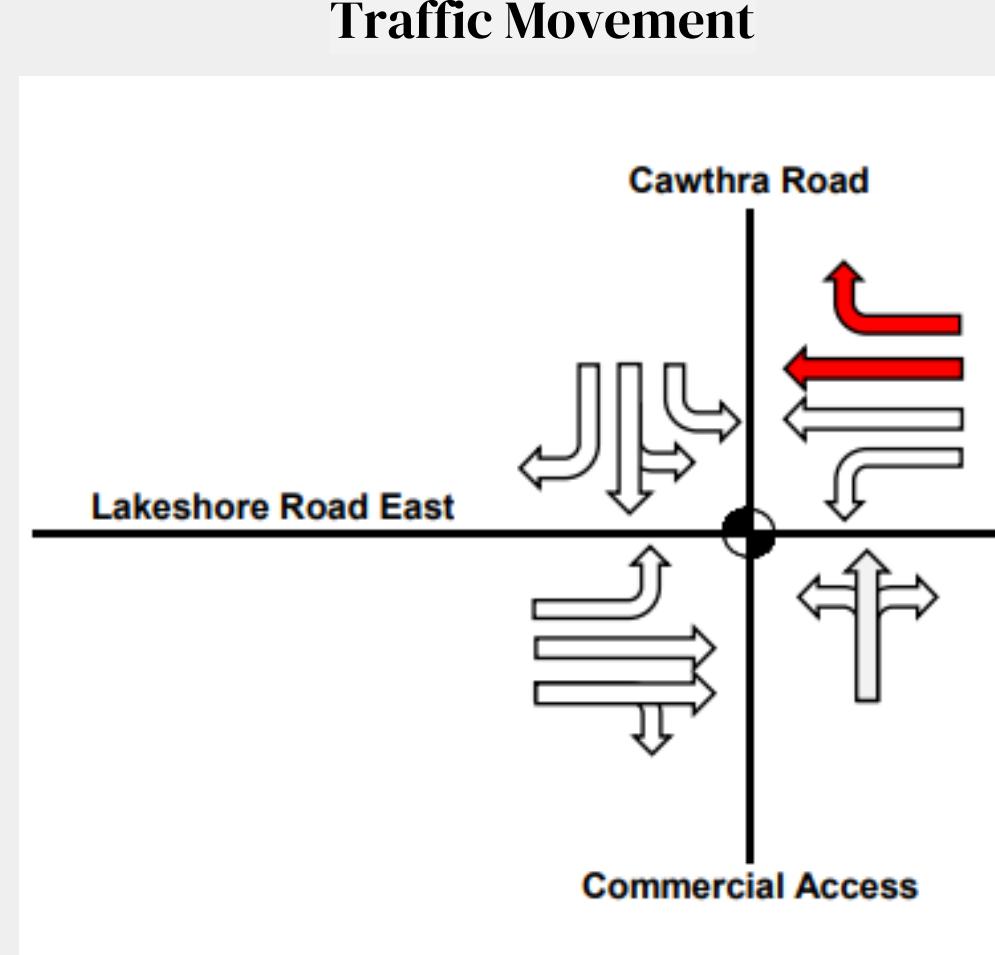
Intersection	Movement of Interest	Input Volume
Haig Boulevard & Lakeshore Road East	NBT	0
	NBR	205
	SBL	2
	SBT	0
	SBR	9
	EBU	0
	EBL	60
	EBT	1582
	EBR	156
	WBU	33
	WBL	147
	WBT	1316
	WBR	41
	NBL	67
	NBT	49
	NBR	142
	SBL	35
	SBT	67
	SBR	56
Dixie Road & Lakeshore Road East	EBU	33
	EBL	575
	EBT	1061
	EBR	20
	WBU	0
	WBL	9
	WBT	1074
	WBR	171
	NBL	3
	NBT	0
	NBR	0
	SBL	151
	SBT	1
	SBR	385
	EBL	15
West Avenue / Montbeck Crescent & Lakeshore Road East	EBT	2153
	EBR	5
	WBL	18
	WBT	1697
	WBR	5
	NBL	8

Intersection	Movement of Interest	Input Volume
Alexandra Avenue & Lakeshore Road East	NBT	2
	NBR	36
	SBL	11
	SBT	0
	SBR	11
	WBT	1722
	WBR	73
	SBR	38
	WBL	0
	WBR	100
	NBT	5
	NBR	0
	SBL	102
	SBT	15
	EBL	4
East Avenue & Rangeview Road	EBT	29
	EBR	29
	WBL	3
	WBT	39
	WBR	13
	NBL	59
	NBT	454
	NBR	9
	SBL	24
	SBT	284
	SBR	24
	EBL	58
	EBT	2
	EBR	4
	WBL	0
Lakefront Promenade & Rangeview Road	WBT	2
	WBR	15
	NBL	2
	NBT	260
	NBR	5
	SBL	5
	SBT	312
	SBR	43
	EBL	48
	EBT	48
	EBR	14

Intersection	Movement of Interest	Input Volume
Lakefront Promenade & Lakeshore Road East	NBL	102
	NBT	1
	NBR	8
	SBL	32
	SBT	1
	SBR	10
	EBU	59
	EBL	0
	EBT	1550
	EBR	276
	WBU	5
	WBL	54
	WBT	1035
	WBR	0
	NBL	324
Ogden Avenue / Street 'G' & Lakeshore Road East	NBT	0
	NBR	136
	EBU	7
	EBL	138
	EBT	1462
	EBR	125
	WBU	2
	WBL	84
	WBT	795
	WBR	73
	NBL	123
	NBT	109
	NBR	152
	SBL	142
	SBT	114
	SBR	47
Hydro Road & Lakeshore Road East	EBU	1
	EBL	3
	EBT	1413
	EBR	319
	WBU	0
	WBL	176
	WBT	986
	WBR	0
	NBL	156

Traffic Movement and Traffic Movement Table

□ This information is the starting point for any transportation analysis.



Traffic Movement Table

Intersection	Movement of Interest	Input Volume
Cawthra Road & Lakeshore Road East	EBL	482
	EBT	1072
	EBR	0
	WBL	3
	WBT	695
	WBR	172
	NBL	0
	NBT	0
	NBR	0
	SBL	238
	SBT	2
	SBR	379

Recap

- Last week, we generated the CSV below, which contains vehicle positions over time.
- Next, we will convert this into a Traffic Movement Table.

	A	B	C	D	E	F	G
1	frame	time_s	vehicle_id	x_m	y_m	img_x	img_y
2	0	0	1	18.868	8.054	319.3	960.8
3	0	0	2	2.319	10.485	242.7	581
4	0	0	3	7.952	7.498	322.4	681.3
5	0	0	4	13.222	11.834	215.6	835
6	0	0	5	7.738	14.745	148.4	728.9
7	0	0	6	13.13	2.472	481.7	773.9
8	1	0.033	1	18.868	8.054	319.3	960.8
9	1	0.033	2	2.319	10.485	242.7	581
10	1	0.033	3	7.952	7.498	322.4	681.3
11	1	0.033	4	13.222	11.834	215.6	835
12	1	0.033	5	7.738	14.745	148.4	728.9
13	1	0.033	6	13.13	2.472	481.7	773.9
14	2	0.067	1	18.901	7.989	321.2	961.5
15	2	0.067	3	7.955	7.498	322.4	681.4
16	2	0.067	2	2.34	10.709	237.5	583.4
17	2	0.067	4	13.22	11.834	215.6	835
18	2	0.067	5	7.734	14.74	148.5	728.8
19	2	0.067	6	13.127	2.477	481.5	773.8
20	3	0.1	2	2.403	11.233	225.3	589.3
21	3	0.1	1	18.892	7.913	323.3	961
22	3	0.1	3	7.961	7.493	322.5	681.5
23	3	0.1	4	13.216	11.833	215.6	834.9
24	3	0.1	5	7.741	14.711	149.1	728.8
25	3	0.1	6	13.126	2.48	481.4	773.8
26	4	0.133	2	2.427	11.502	219.2	592.2
27	4	0.133	3	7.967	7.492	322.6	681.6
28	4	0.133	4	13.215	11.832	215.6	834.8
29	4	0.133	5	7.737	14.698	149.4	728.6
30	4	0.133	1	18.877	7.868	324.6	960.4
31	4	0.133	6	13.127	2.48	481.4	773.8
32	5	0.167	2	2.476	11.816	212.1	595.9
33	5	0.167	3	7.95	7.491	322.6	681.2



Traffic Movement Table

Intersection	Movement of Interest	Input Volume
Cawthra Road & Lakeshore Road East	EBL	482
	EBT	1072
	EBR	0
	WBL	3
	WBT	695
	WBR	172
	NBL	0
	NBT	0
	NBR	0
	SBL	238
	SBT	2
	SBR	379

Format of our Traffic Movement Table vs City Projects

Format of our Traffic Movement Table

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Minute	North_L	North_T	North_R	South_L	South_T	South_R	East_L	East_T	East_R	West_L	West_T	West_R
2	1	10	30	5	8	28	6	12	35	5	9	27	5
3	2	12	32	6	9	30	5	11	38	6	10	29	6
4	3	11	28	4	7	26	5	13	36	4	8	25	4
5	4	9	29	5	8	27	6	12	37	5	9	28	5
6	5	11	31	6	9	29	5	11	35	6	10	27	6
7	6	10	30	5	8	28	6	12	36	5	9	26	5
8	7	12	32	6	9	30	5	13	38	6	10	29	6
9	8	11	28	4	7	26	5	12	35	4	8	25	4
10	9	9	29	5	8	27	6	11	37	5	9	28	5
11	10	11	31	6	9	29	5	12	36	6	10	27	6
12	11	10	30	5	8	28	6	12	35	5	9	26	5
13	12	12	32	6	9	30	5	13	38	6	10	29	6
14	13	11	28	4	7	26	5	12	36	4	8	25	4
15	14	9	29	5	8	27	6	11	37	5	9	28	5
16	15	11	31	6	9	29	5	12	35	6	10	27	6

Format of a Traffic Movement Table in City Projects

Intersection	Movement of Interest	Input Volume
Cawthra Road & Lakeshore Road East	EBL	482
	EBT	1072
	EBR	0
	WBL	3
	WBT	695
	WBR	172
	NBL	0
	NBT	0
	NBR	0
	SBL	238
	SBT	2
	SBR	379



(veh/h)

Recap: Object Detection and Tracking Using SimJamCV

Steps:

1. Download Week3b.Material.zip and Extract it
2. Run SimJamCVAnalytics.py
3. Install Dependencies
4. Choose input video file
5. Adjust Detection/Tracking Parameters
6. Select YOLO Algorithm

Steps:

7. Set output directory
8. Run Application
9. Preprocessing
10. Algorithm Running
11. Understanding Output
12. Performance Analytics
13. Map lane_metric.csv → Traffic Movement Table

Step 12. Performance Analytics

➤ Download the Week3b.Material.zip and Extract it

➤ Run SimJamCVAnalytics.py

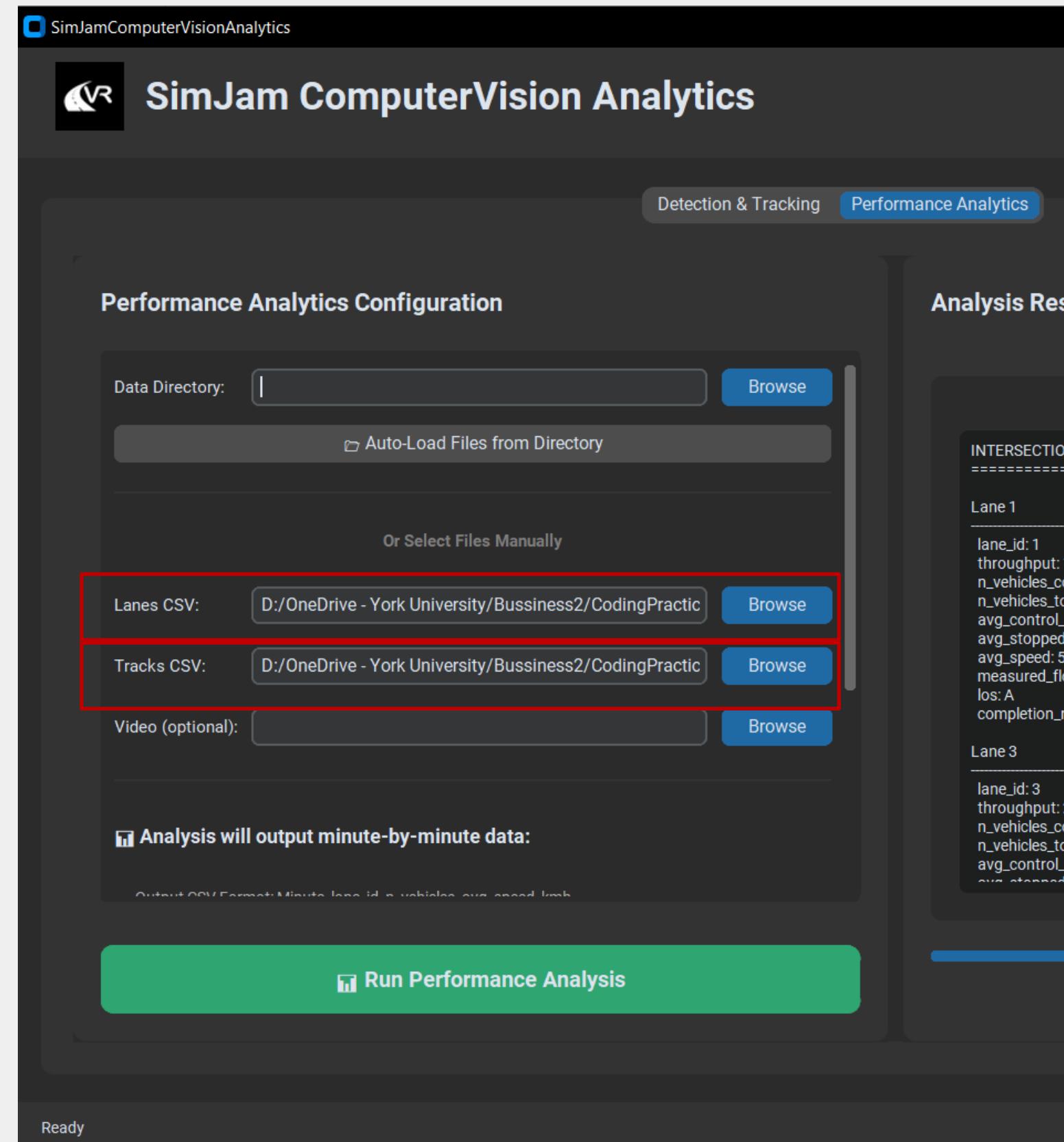
➤ Open the “Performance Analytics” tab

1. Select Lanes CSV (lanes.csv)

2. Select Tracks CSV (vehicle_tracks_xy.csv))

➤ Click Run Performance Analysis

Note: The CSV files are located in the InputVideo folder.



Step 12. Performance Analytics

- Check the output CSV

1. Open Lane_Metric.csv

2. It reports, for each minute and lane:

n_vehicles = number of vehicles detected in that lane during that minute

avg_speed_kmh = average speed (km/h) of those vehicles during that minute



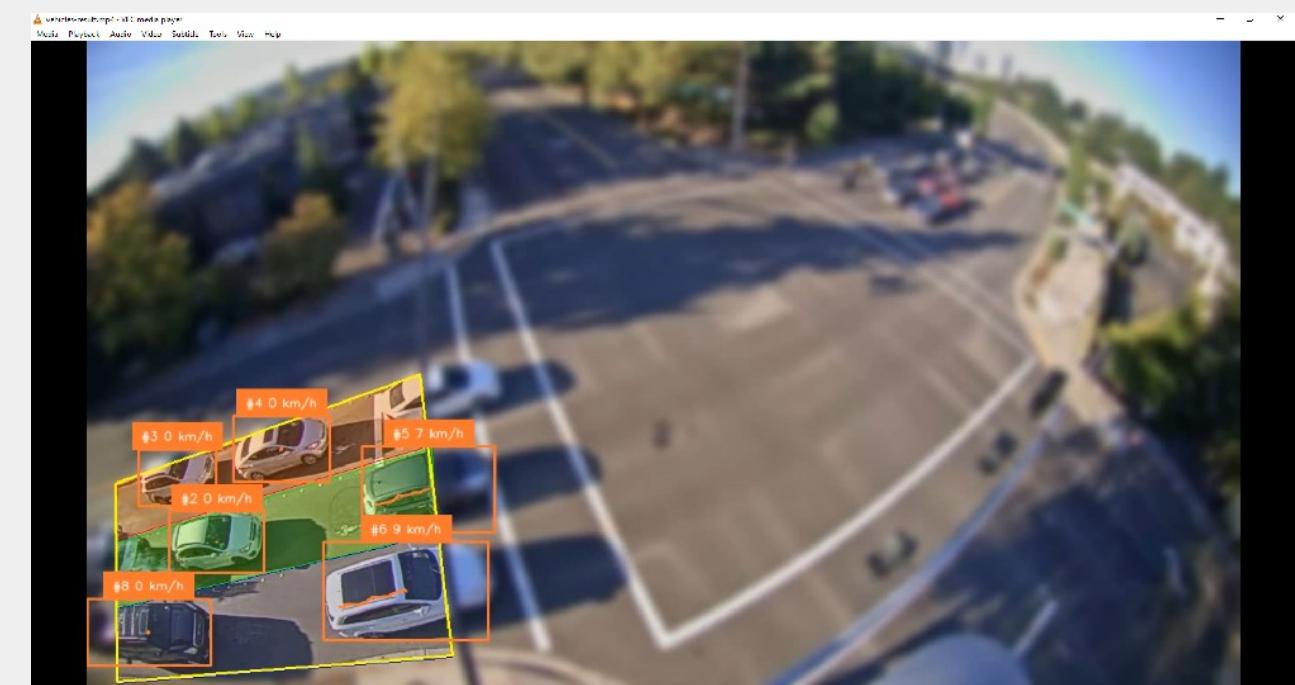
A	B	C	D	E
1	Minute	lane_id	n_vehicles	avg_speed_kmh
2	1	1	13	11.61
3	1	2	9	8
4	1	3	2	1.63
5				

- Quick validation using the video

1. Open vehicles-result.mp4

2. Manually count the vehicles in each lane (for a selected minute)

3. Compare your counts with Lane_Metric.csv to confirm they match



Deliverable A

- Verify that the vehicle counts per lane in the video match the CSV.
- If there is a mismatch:
 - Identify the vehicle that caused it (ID / screenshot timestamp)
 - Explain the reason (what went wrong in detection, tracking, or lane assignment)

Deliverable A

- In Week3b.Material → Copy and Paste
- Create four Sub Folders as “Eastbound”, Northbound, Westbound, Southbound
- Transfer the Lane_Metric.csv to the Correspondent Movement (Eastbound)

Step 13. Map lane_metric.csv → Traffic Movement Table

➤ Goal: Lane_Metric.csv is per lane_id, but your final table is per movement (North_L, East_T, ...).

EastBound

A	B	C	D
Minute	lane_id	n_vehicles	avg_speed_kmh
1	1	11	11.34
2	1	9	7.39
3	1	2	1.54
4	2	1	43.39
5	2	3	49.38
6	2	2	8.36
7	2	3	34.52
8	3	1	45.49
9	3	2	8.27
10	3	8	8.27
11	4	1	3.02
12	4	2	7.89
13	4	2	18.97
14	5	1	49.38
15	5	2	8.36
16	5	3	34.52
17	6	1	49.38
18	6	2	49.38
19	6	3	8.36
20	7	1	34.52
21	7	2	34.52
22	7	3	8.36
23	8	1	34.52
24	8	2	34.52
25	8	3	11.34
26	9	1	7.89
27	9	2	18.97
28	9	1	43.39
29	10	5	8.27
30	10	2	43.39
31	10	3	8.27
32	11	1	1.54
33	11	2	43.39
34	11	3	8.27
35	12	1	43.39
36	12	2	8.27
37	12	3	45.49
38	13	1	8.27
39	13	2	3.02
40	13	3	7.89
41	14	1	18.97
42	14	2	7.89
43	14	3	8.27
44	15	1	3.02
45	15	2	3.02

NorthBound

A	B	C	D
Minute	lane_id	n_vehicles	avg_speed_kmh
2	1	11	11.34
3	1	9	7.39
4	1	2	1.54
5	2	1	43.39
6	2	3	49.38
7	2	2	8.36
8	3	7	34.52
9	3	8	45.49
10	3	3	8.27
11	4	1	3.02
12	4	0	7.89
13	4	2	18.97
14	5	14	49.38
15	5	3	8.36
16	5	5	34.52
17	6	1	49.38
18	6	7	49.38
19	6	6	8.36
20	7	3	34.52
21	7	2	34.52
22	7	3	8.36
23	8	1	34.52
24	8	4	34.52
25	8	1	11.34
26	9	1	7.89
27	9	12	18.97
28	9	1	43.39
29	10	10	
30	10	10	
31	10	10	
32	11	11	
33	11	11	
34	11	11	
35	12	12	
36	12	12	
37	12	12	
38	13	13	
39	13	13	
40	13	13	
41	14	14	
42	14	14	
43	14	14	
44	15	15	
45	15	15	

WestBound

A	B	C	D
Minute	lane_id	n_vehicles	avg_speed_kmh
2	1	11	11.34
3	1	9	7.39
4	1	2	1.54
5	2	1	43.39
6	2	3	49.38
7	2	2	8.36
8	3	3	34.52
9	3	8	45.49
10	3	3	8.27
11	4	1	3.02
12	4	4	7.89
13	4	4	18.97
14	5	14	49.38
15	5	5	8.36
16	5	5	34.52
17	6	1	49.38
18	6	6	49.38
19	6	6	8.36
20	7	7	34.52
21	7	7	34.52
22	7	7	8.36
23	8	8	34.52
24	8	8	34.52
25	8	8	11.34
26	9	9	7.89
27	9	9	18.97
28	9	9	43.39
29	10	10	
30	10	10	
31	10	10	
32	11	11	
33	11	11	
34	11	11	
35	12	12	
36	12	12	
37	12	12	
38	13	13	
39	13	13	
40	13	13	
41	14	14	
42	14	14	
43	14	14	
44	15	15	
45	15	15	

SouthBound

A	B	C	D
Minute	lane_id	n_vehicles	avg_speed_kmh
2	1	1	11.34
3	1	1	7.39
4	1	2	1.54
5	2	1	43.39
6	2	2	49.38
7	2	3	8.36
8	3	3	34.52
9	3	8	45.49
10	3	3	8.27
11	4	1	3.02
12	4	4	7.89
13	4	4	18.97
14	5	14	49.38
15	5	5	8.36
16	5	5	34.52
17	6	1	49.38
18	6	6	49.38
19	6	6	8.36
20	7	7	34.52
21	7	7	34.52
22	7	7	8.36
23	8	8	34.52
24	8	8	34.52
25	8	8	11.34
26	9	9	7.89
27	9	9	18.97
28	9	9	43.39
29	10	10	
30	10	10	
31	10	10	
32	11	11	
33	11	11	
34	11	11	
35	12	12	
36	12	12	
37	12	12	
38	13	13	
39	13	13	
40	13	13	
41	14	14	
42	14	14	
43	14	14	
44	15	15	
45	15	15	



Traffic Movement Table

A	B	C	D	E	F	G	H	I	J	K
---	---	---	---	---	---	---	---	---	---	---

Step 13.a. Camera Orientation & North Direction (Google Maps)

1. Open Google Maps and go to:

(47.6230411248205, -122.18553244180727)

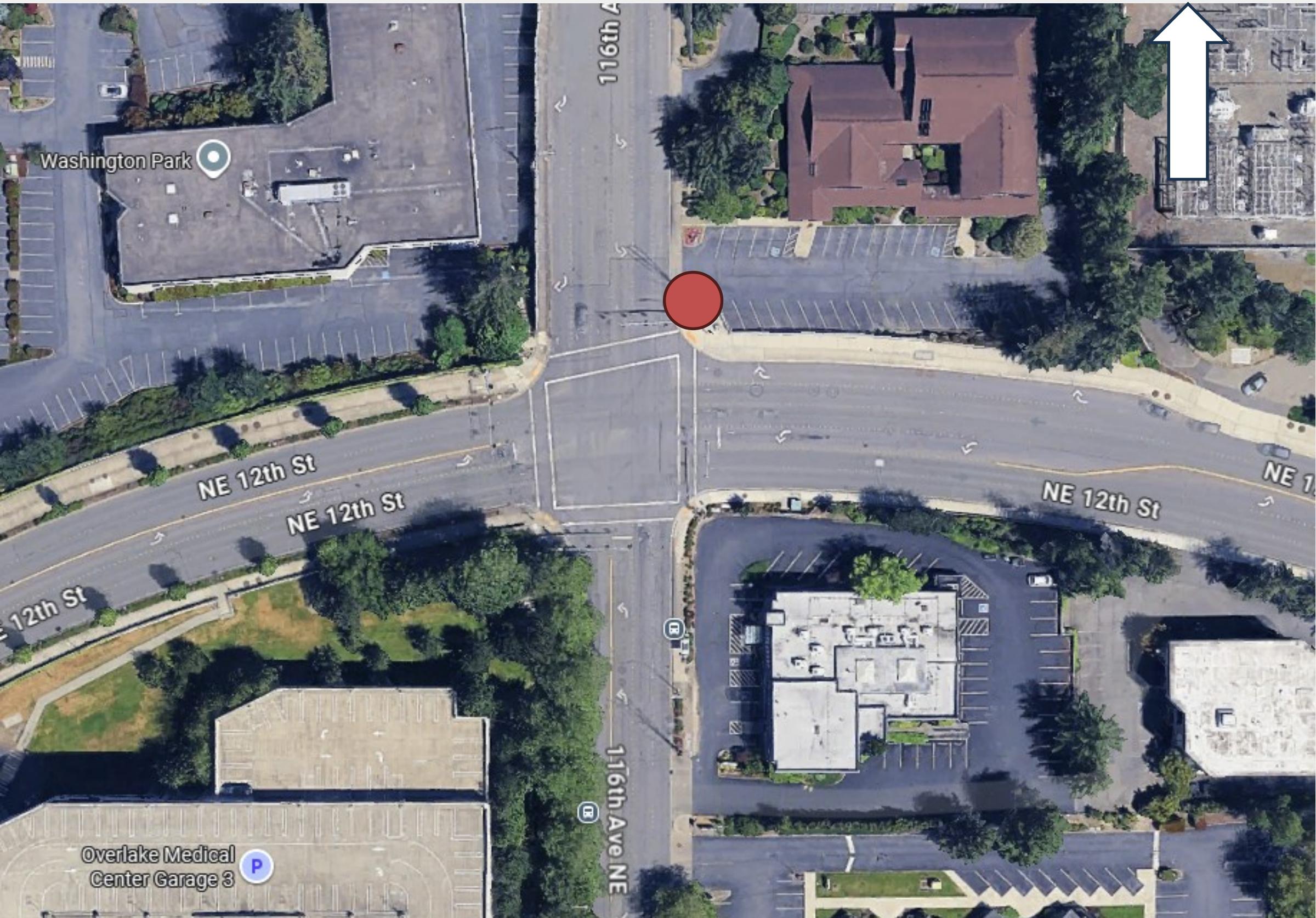
2. Zoom in until the intersection matches the video view.

3. Take a screenshot and paste it into PowerPoint.

4. Paste it in Powerpoint

5. Using PowerPoint drawing tools, add a North arrow (white arrow)

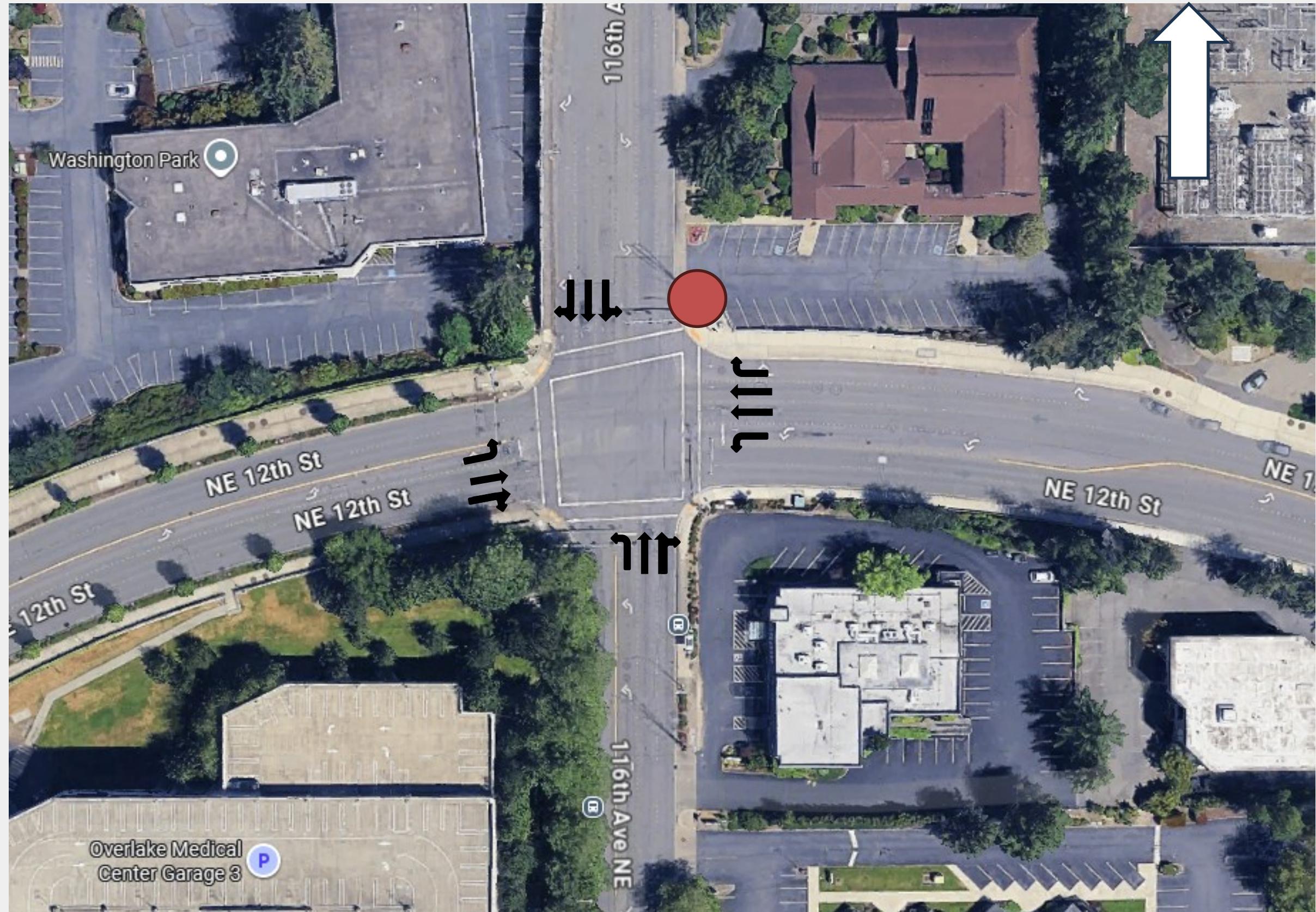
6. Mark the camera location with a red circle.



Step 13.b. Traffic Movement on Google Map

7. Using arrows, determine the through and turning movements for each approach lane at the intersection

8. If a lane serves both through and right-turn (or left-turn), draw/mark both movements.



Step 13.b. Traffic Movement on Google Map

9. Determine Eastbound, Westbound,
Northbound and Southbound



Step 13.c. Traffic Movement on Video

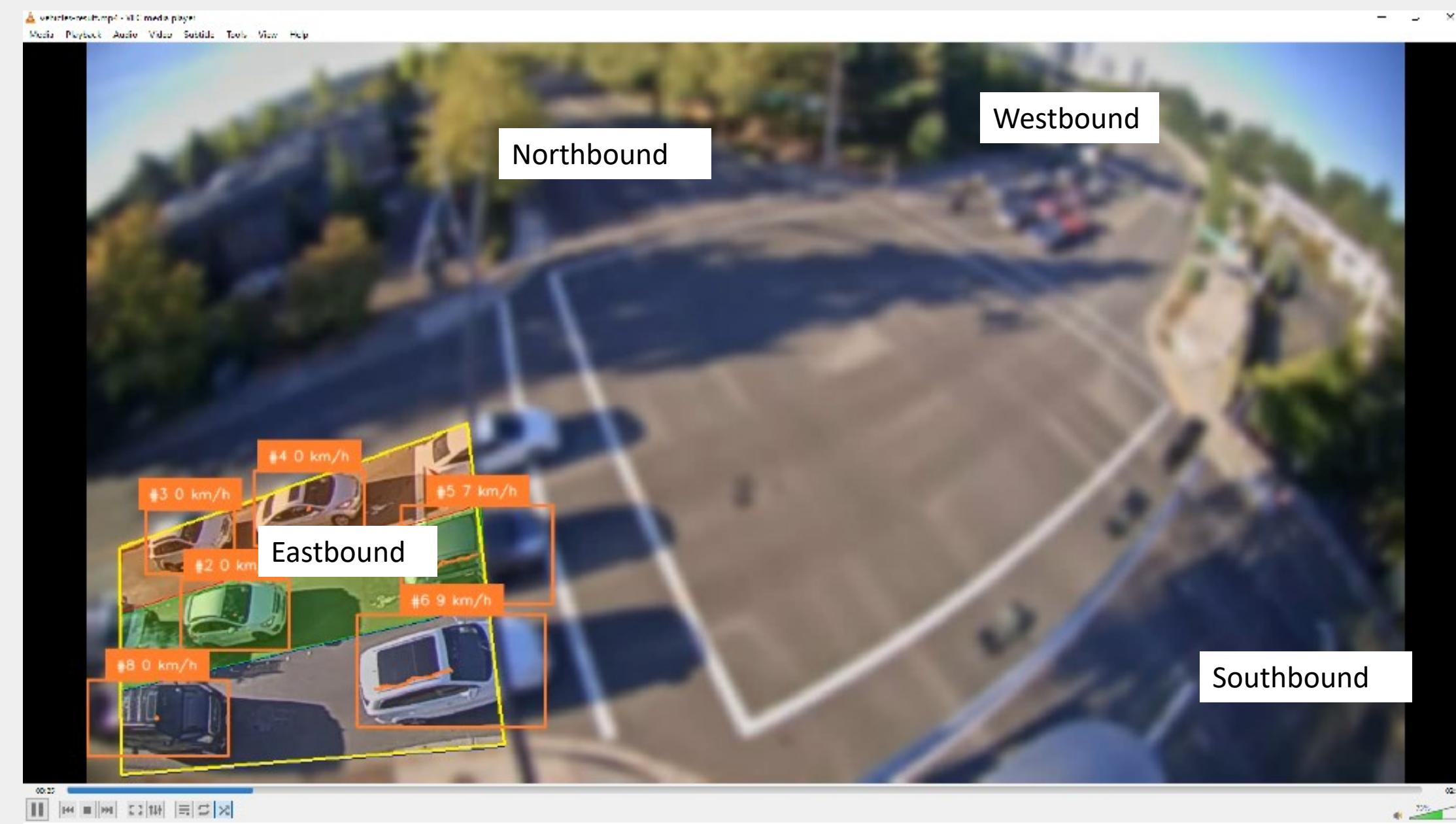
10. Determine Eastbound, Westbound,

Northbound and Southbound in the Output

Video

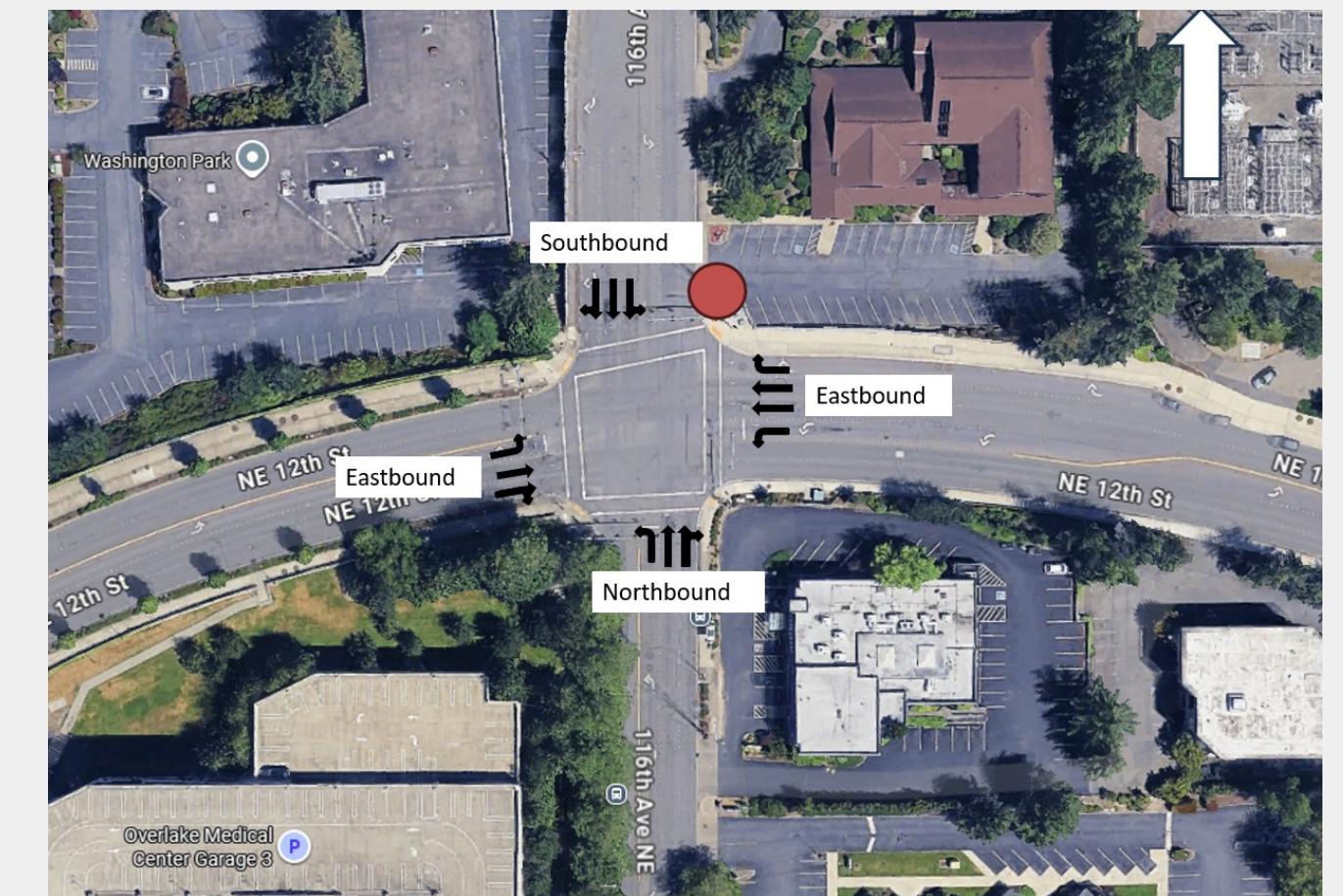
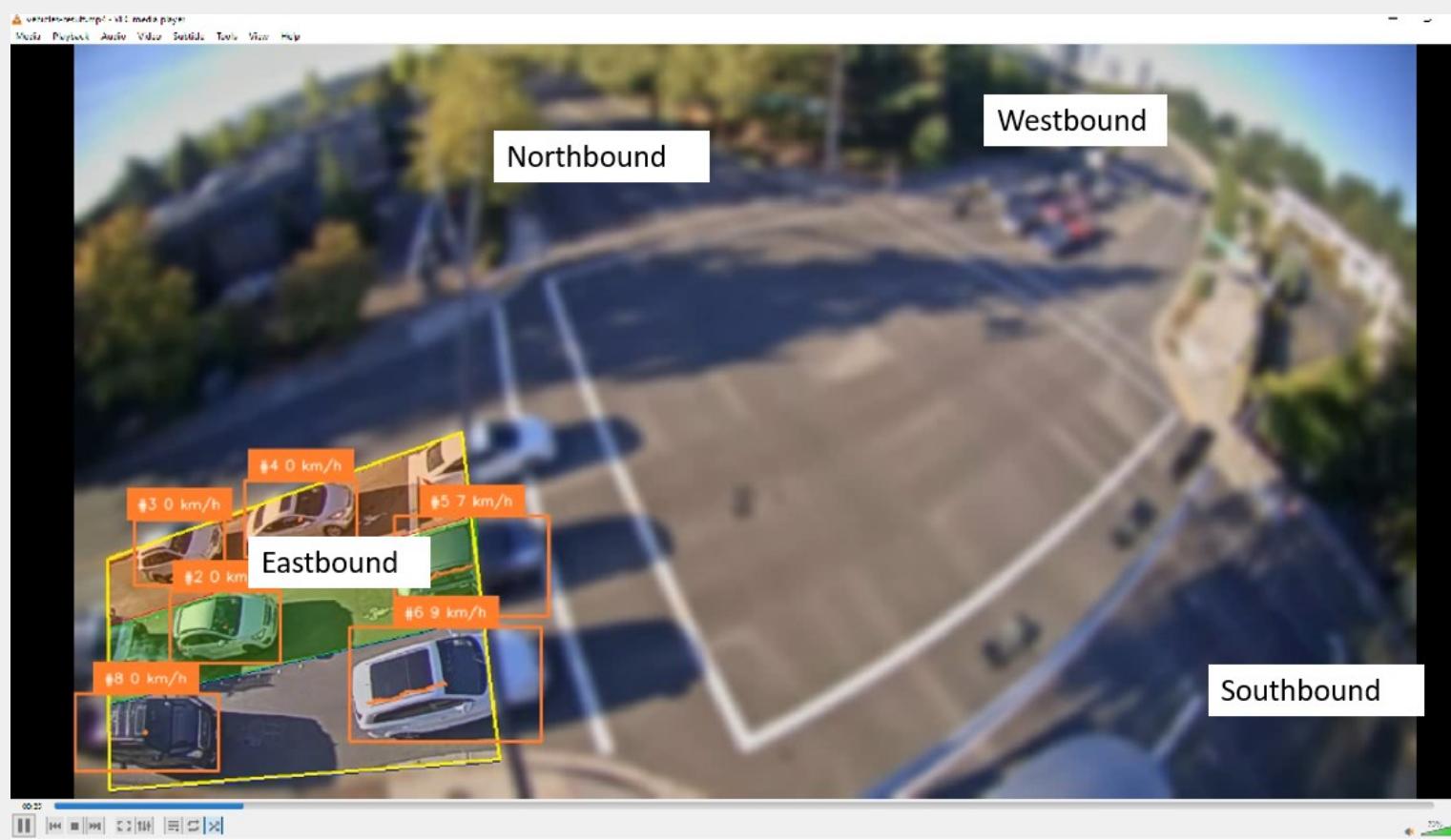
11. Take a screenshot and paste it into

PowerPoint.



Deliverable B

12. Compare the Video with Google map, whats the two main differences?



Deliverable C

13. Open Folder “Lane_Metric_15_Min”

14. Open Folder Eastbound

15. Open Lane_Metric.csv

15. Create a new CSV with the same format as the table

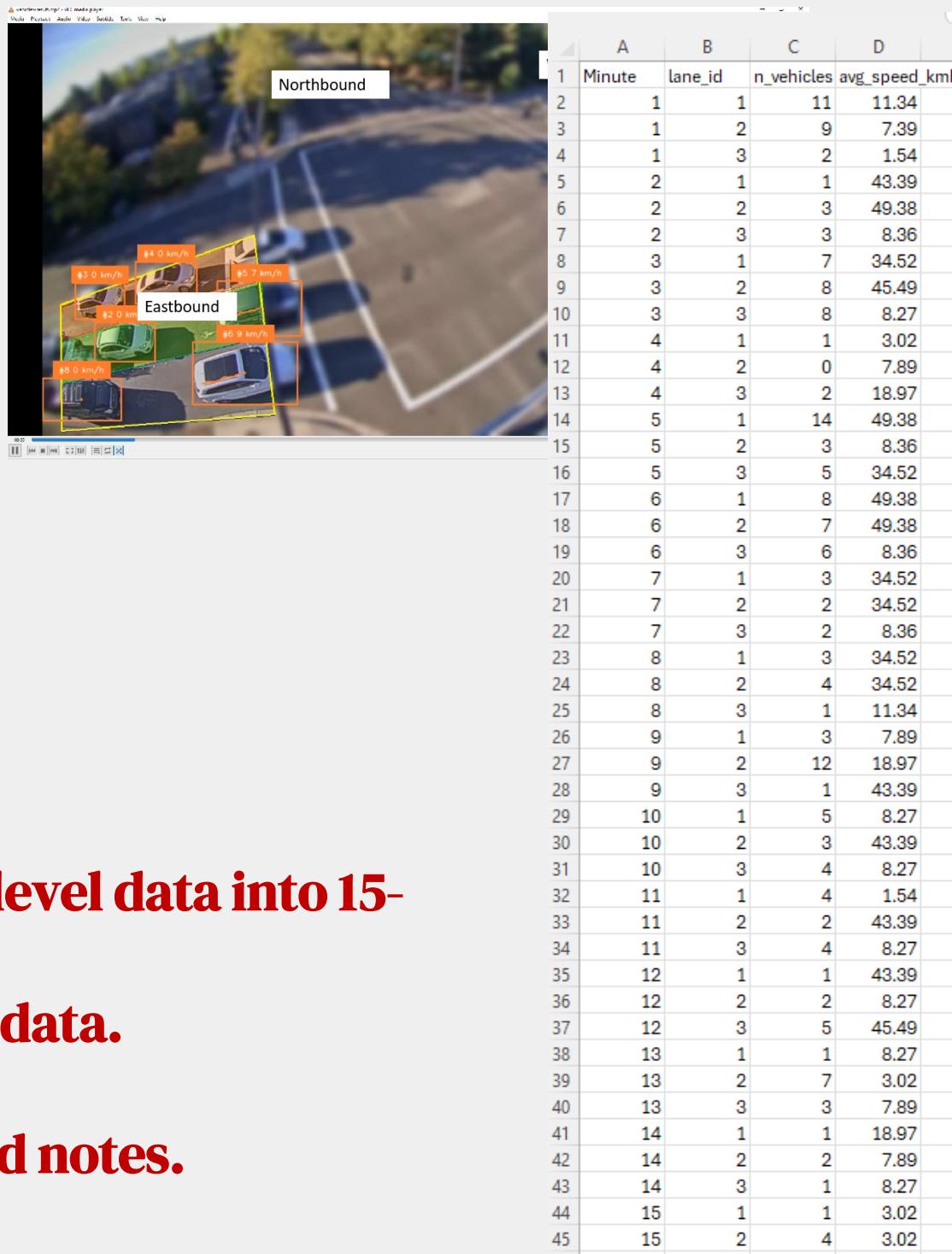
(Minute + 12 movement columns).

16. Name it as “Interval Observed Data.csv”

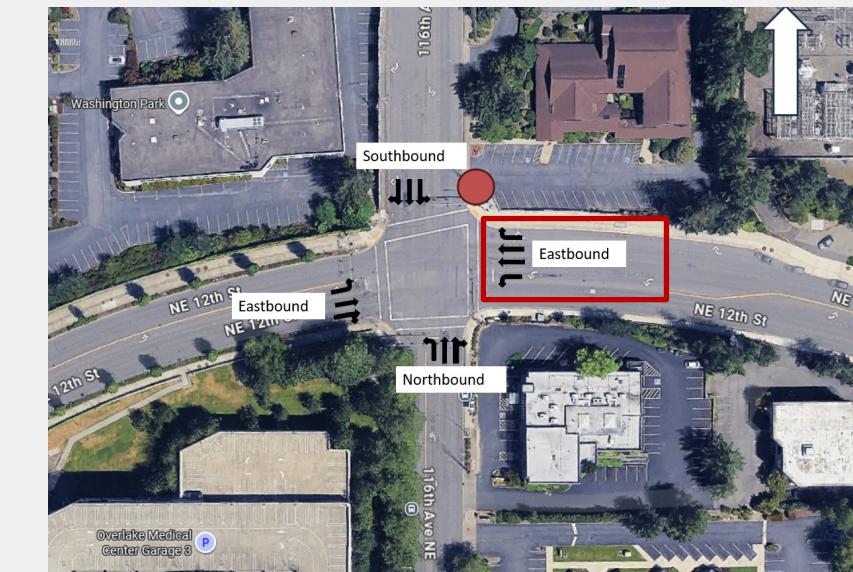
17. For each minute, fill each cell with the number of vehicles (n_vehicles) from Lane_Metric.csv for the

Deliverable C

Example:



Camera view: Eastbound



- ❑ Convert 15-minute lane-level data into 15-minute movement-level data.
 - ❑ Next slides: key rules and notes.

Deliverable C

- 13. If there are two through lanes (e.g., eastbound), sum them and enter the total in East_T.**
- 14. If a movement includes right + through (e.g., northbound), assume 20% right-turn and 80% through volume.**
- 15. If a movement includes left + through (e.g., southbound), assume 20% left-turn and 80% through volume.**

Deliverable C

- Repeat the same process for the other approaches (westbound, southbound, and northbound).

Deliverable C

- ❑ Once you create the CSV for each traffic movement, create a new CSV named “15-Min Observed Data.csv”.
 - ❑ The CSV format should match the template shown below.
 - ❑ Aggregate each traffic movement over 15 minutes and populate the CSV.

15-Min Observed Data.csv

Step 13. Map lane_metric.csv → Traffic Movement Table

Final: Two CSV files for Output Data

Traffic Volume per approach per min

A	B	C	D	E	F	G	H	I	J	K	L	M	
1	Minute	North_L	North_T	North_R	South_L	South_T	South_R	East_L	East_T	East_R	West_L	West_T	West_R
2	1												
3	2												
4	3												
5	4												
6	5												
7	6												
8	7												
9	8												
10	9												
11	10												
12	11												
13	12												
14	13												
15	14												
16	15												

Filled Numbers



Min Observed Data.csv

Traffic Volume per approach per 15 min

A	B	C	D	E	F	G	H	I	J	K	L	M	
1	Minute	North_L	North_T	North_R	South_L	South_T	South_R	East_L	East_T	East_R	West_L	West_T	West_R
2	all												

Filled Numbers



15Min Observed Data.csv