Estimation of Queue Lengths using Unmanned Aerial Data

Submitted for UAS Collected Traffic Data Analysis (UAS4T) Competition

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Introduction

Traffic delays and queues are key parameters in determining the quality of service of signalized intersections. In this study, we used shockwave analysis on real-time video data, which were collected using a drone, to characterize the various queues on three signalized approaches. Specifically, for all three specified areas shown in Figure 1, we estimated the: i) maximum queue length, ii) lane the maximum queue length occurred, iii) coordinates of the start and end of the maximum queue, iv) timestamp of the maximum queue occurrence, and v) whether, when and where a spillback occurred.

Dataset and Approach

This study used a 14-min videotape at a three-way signalized intersection in Athens, Greece. The tape was taken using a drone hanging over a high point at the center of the intersection to cover the three intersection approaches, as shown in Figure 1. The tape was then converted to second-by-second trajectories for all types of vehicles including cars, taxis, powered two-wheelers, buses, medium and heavy vehicles.

The first step entailed using Google Earth to divide each polygon into smaller sub-polygons representing the lanes in each of the polygons. We visually determined the number and direction of each lane. The second step entailed identifying the lane vehicles were on. This was achieved using the instantaneous longitude and latitude. In order to validate the lane allocations, the origin-destination for each trajectory was identified and checks were done to ensure movements were in the correct lanes. Subsequently, we created lane-specific time-space diagrams (vehicle trajectories) that were associated with each sub-polygon. The third step entailed applying shockwave analysis to determine the backward formation and backward recovery waves for each lane-specific queue. This was used to identify any queue spillbacks past the upstream edge of the polygon (the zero reference, in which distances were in the negative

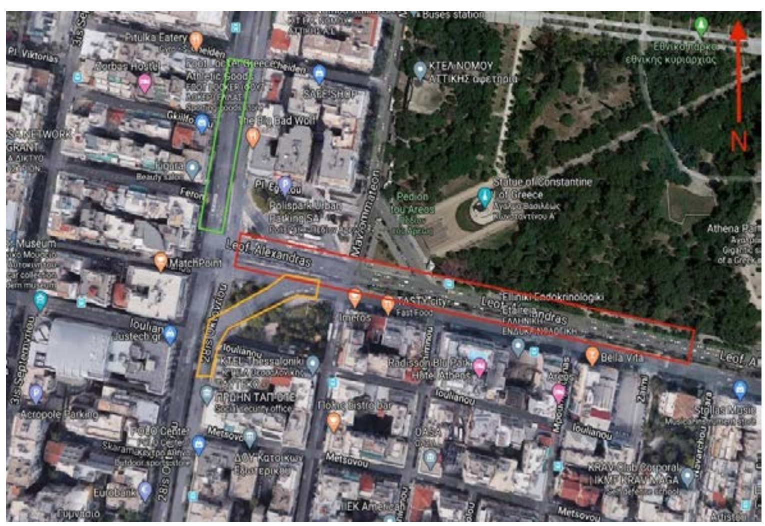

Figure 1. Study area.

range). We assumed that a vehicle traveling at **a speed less than or equal to the typical pedestrian speed of 1.2 m/s was stopped**. We used MATLAB for preprocessing the data and R for the data analysis.

Results

We constructed the time-space diagrams for each lane on each approach, as shown in Figure 2. The green polygon consists of five lanes (four lanes plus a left turn pocket lane). We labeled the pocket lane, the leftmost lane, L1 and increased the counter until the rightmost lane, which is labeled L5. The orange polygon consists of two lanes, in which we labeled the leftmost lane L1 and the right lane L2. The red polygon consists of three lanes and two additional traffic signals. **Unlike what was done in the other two polygons, the rightmost lane is labeled L1**, the leftmost lane L3, and the middle lane L2. Using the time-space diagram we were able to identify the maximum queue length in each lane during the monitoring period, as shown in Table 1. The table demonstrates that the maximum queue length in the green polygon occurred in L2 (leftmost upstream of the left turn pocket lane) at a length of 102.7m, about 98.6m in L2 (rightmost) of the orange polygon, and 296.3m in L1 (rightmost) of the red polygon.

Table 1. Maximum queue length in each lane of the study area.

Polygon	Lane	Max length (m)	Timestamp	Start Lat.	Start Long.	End Lat.	End Long.
Green	1 (L-P)	25.0	565.04	37.99190	23.73136	37.99211	23.73140
	2 (L)	102.7	350.20	37.99225	23.73141	37.99280	23.73154
	3 (M-L)	102.2	346.00	37.99229	23.73139	37.99280	23.73150
	4 (M-R)	97.6	529.56	37.99275	23.73148	37.99275	23.73148
	5 (R)	98.6	783.12	37.99200	23.73121	37.99277	23.73142
Orange	1 (L)	89.6	550.68	37.99158	23.73135	37.99108	23.73116
	2 (R)	98.9	83.16	37.99165	23.73188	37.99107	23.73121
Red	1 (R)	296.3	303.24	37.99183	23.73158	37.99128	23.73485
	2 (M)	295.1	170.20	37.99176	23.73156	37.99125	23.73483
	3 (L)	274.4	165.32	37.99175	23.73157	37.99126	23.73459

* L-P (left pocket lane), L (leftmost lane), M-L (middle left lane), M-R (middle right lane), M (middle lane), R (rightmost lane).

Moreover, we used the time-space diagram to identify spillbacks on each lane during the monitoring period. Table 2 summarizes the results for the various spillbacks.

Table 2. Spillback results.

Polygon	Lane	Timestamp (s)	Polygon	Lane	Timestamp (s)
Green*	2 (L)	350.00	**Orange**	2 (R)	242.16
	3 (M-L)	350.00		2 (R)	264.56
Red	1 (R)	809.40		2 (R)	375.88
	2 (M)	544.84		2 (R)	388.08
	2 (M)	648.40		2 (R)	422.52
	2 (M)	738.24		2 (R)	475.72
	2 (M)	809.80		2 (R)	519.68
	3 (L)	659.52		2 (R)	562.40
Orange	1 (L)	313.32		2 (R)	646.04
	1 (L)	493.00		2 (R)	697.92
	2 (R)	103.32		2 (R)	745.16
	2 (R)	198.24		2 (R)	811.40

* Spillback results for the green polygon are approximate since there are no trajectory information upstream of the polygon.

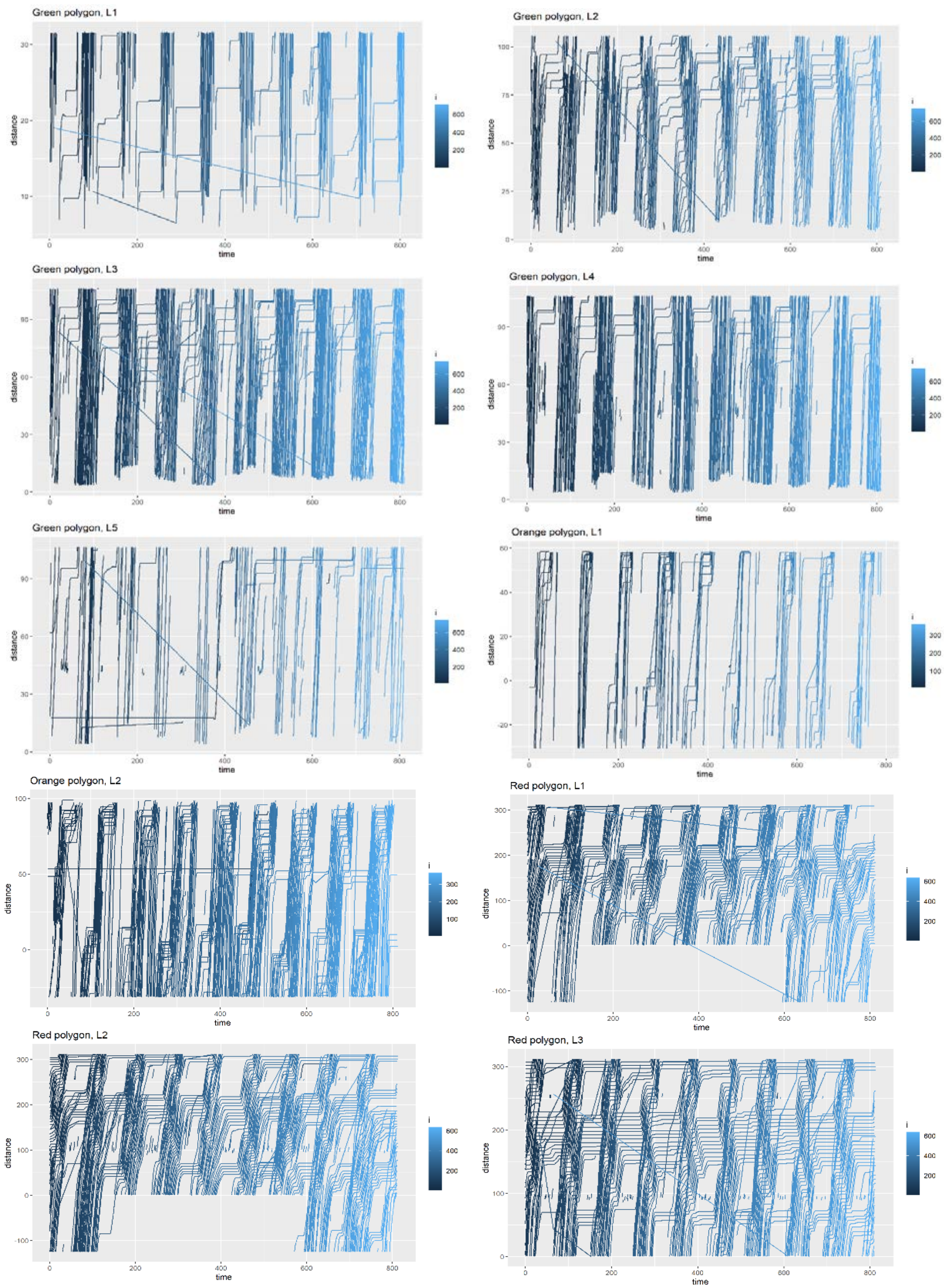

Figure 2.Time-space diagram for each lane in the study area.