A Further Empirical Results

An example of the ground truth and resulting estimate can be seen in Fig. 6. Here, the traffic data is given at the two red points, and the blue line is the estimated state. The green line is the ground truth of the traffic, which is not visible to the state estimator.

In these plots (shown in Fig. 7), we can see that the state estimate (red) closely tracks the ground truth (green). The maximum absolute difference is bounded by 0.08 cars/car length. The individual vehicle motion also tracks the ground true, but with greater error. Specifically, the reconstructed vehicle flow tends to over-shoot the density tracking. The maximum error for the individual car tracking is about 0.2 cars/car length.

Below, in Fig. 8, similar plots for the lane-mean velocities are presented. Here, we see again that the state estimate tracks the ground state well. In this case, the individual vehicle motion follows the state estimation velocity almost exactly, as expected. The only variation is due to the reactive behavior of the virtual vehicle agents to avoid collisions. For both, the worst error observed is less than 3.7 m/s.

The root mean square (RMS) of the error for the both the state estimate (Macro) and the individual vehicle motion (Agent) are presented below in Table 1.

Lane	Sim	Density RMS error	Velocity RMS error
0	Agent	0.11	1.00
0	Macro	0.08	1.26
1	Agent	0.06	1.89
1	Macro	0.05	1.97
2	Agent	0.05	1.13
2	Macro	0.04	1.14
3	Agent	0.05	2.56
3	Macro	0.04	2.56
4	Agent	0.06	1.97
4	Macro	0.06	2.00
5	Agent	0.05	2.39
5	Macro	0.03	2.42

Table 1: *Root mean square error between the macroscopic state estimate (Macro) and the ground truth and between the reconstructed individual vehicle motion (Agent) and the ground truth. Density is in units of cars per car length. Velocity in meters per second.*

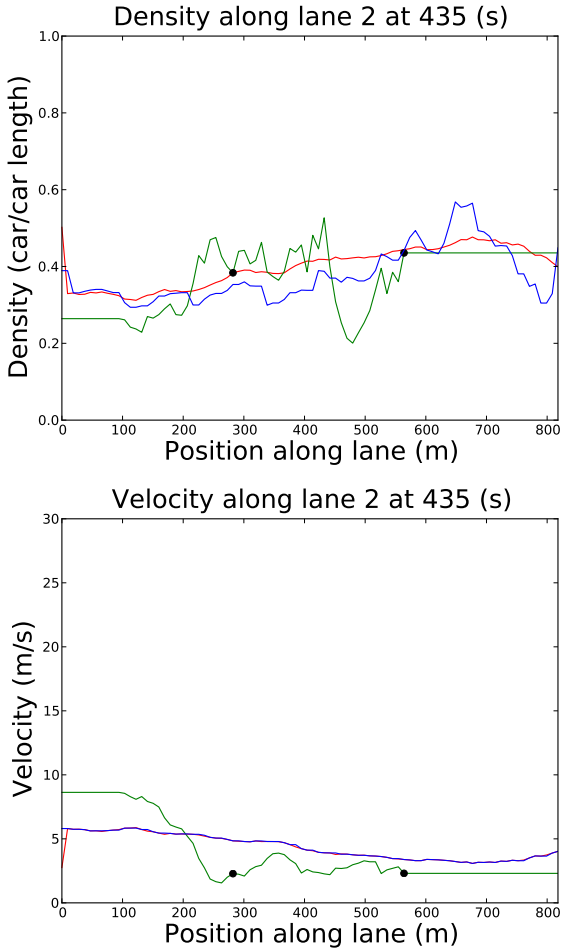

Figure 6: *Example images showing the ground truth (green lines), sensor data (black dots), macroscopic state estimate (red line), virtual traffic reconstruction (blue line) for density and velocity. This example shows same characteristics of the approach: the estimate is done with a very restricted view of the underlying state (the available sensor data is only the black dots), road-mean matching is good, but at there are local disparities. The area where the green line is flat is where the ground truth data is not available.*

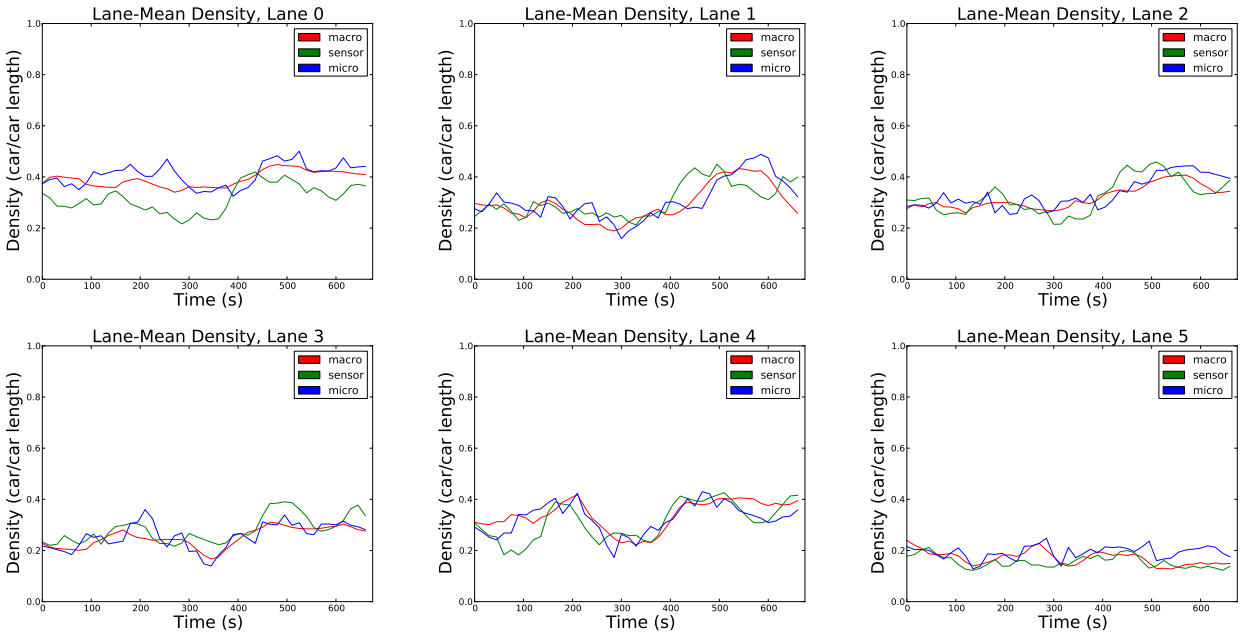

Figure 7: *The lane-mean density for each of the six lanes. Lane 0 is the right-most lane, connected to the ramps, and lane 5 is the left-most lane or the 'car-pool' lane. The* **green** *line is the ground truth, the* **red** *line is the state estimate, and the* **blue** *line is the agent-based simulation (i.e. detailed reconstruction).*

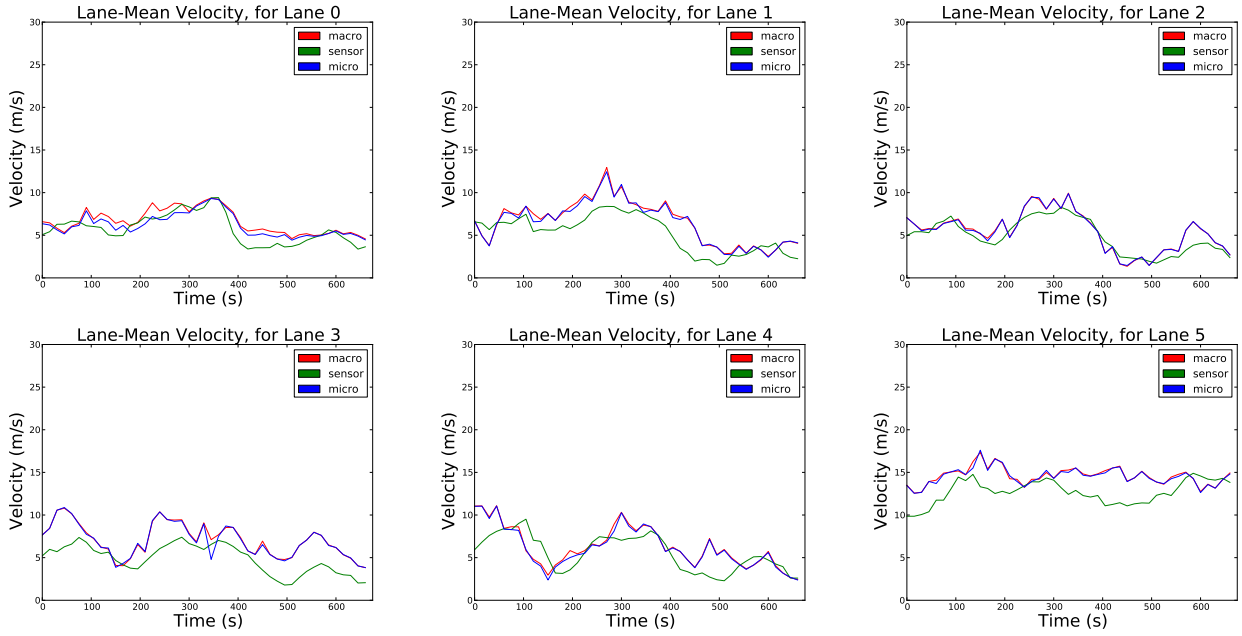

Figure 8: *The lane-mean velocity for each of the six lanes. Lane 0 is the right-most lane, connected to the ramps, and lane 5 is the left-most lane or the 'car-pool' lane. The* **green** *line is the ground truth, the* **red** *line is the state estimate, and the* **blue** *line is the agent-based simulation (i.e. detailed reconstruction).*