Stabilizing String Stability of platoon of vehicle via Computer Vision technique

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ABSTRACT

Traffic congestion creates inconvenience and safety problems across the world, and we need better techniques for modeling and understanding it. **String Stability(SS)** is one theoretical approach that indicates uniform spacing of all the elements of the interconnected arrangement for all points [1,2].There are many state-of-art numerical methods presented earlier, but there is undoubtedly a lack of work regarding the application of SS in various conditions. ***Therefore, I propose novel String Stability research using Computer Vision(CV) and Machine Learning(ML) techniques.***

Study Aims

Aim 1: **Aerial drone** will be utilized on the crowded highway intersection to collect high-quality, real-life traffic videos, and their meta-data. The dataset will be publicized to engage CV scientists and communities on SS work.

Aim 2: **A novel CV and ML algorithms for maintaining SS** of a platoon of the vehicle will be developed using mathematical groundwork presented by D.Swaroop and J.K. Hendrik.

Aim 3: Performance will be observed in open-source **Robot Operating System(ROS) simulation software** and tested with a platoon of autonomous ground vehicle trained with the novel CV and ML algorithms.

Experimental Design

CV technique: A CV algorithm such as **YOLO9000**[3] will be used to generate vehicle bounding boxes that I will use to derive position values with respect to the size of the collected videos.

SS Model:

A simple longitudinal vehicle dynamic model for the vehicle in the platoon can be calculated by

$$x_i = \frac{(u_i - c_i x_{ki}^2 - F_i)}{M_i}$$

Where x_i is the position of the i^{th} vehicle in the platoon with respect to a frame, u_i represents the braking effort, $c_i x_{ki}^2$ is the aerodynamic drag force, and F_i is the tire drag acting on the i^{th} vehicle. **The vehicular spacing error** is given by

$$e_i(t) = x_i(t) - x_{(i-1)}(t) = L_i$$

Where L_i is the desired constant vehicular spacing. **The spacing error dynamics** are given by

$$\frac{1}{(1+q_3)}[e_{(i-1)} + (q_1 + \lambda)e_{(i-1)} + q_1 \lambda e_{(i-1)}]$$

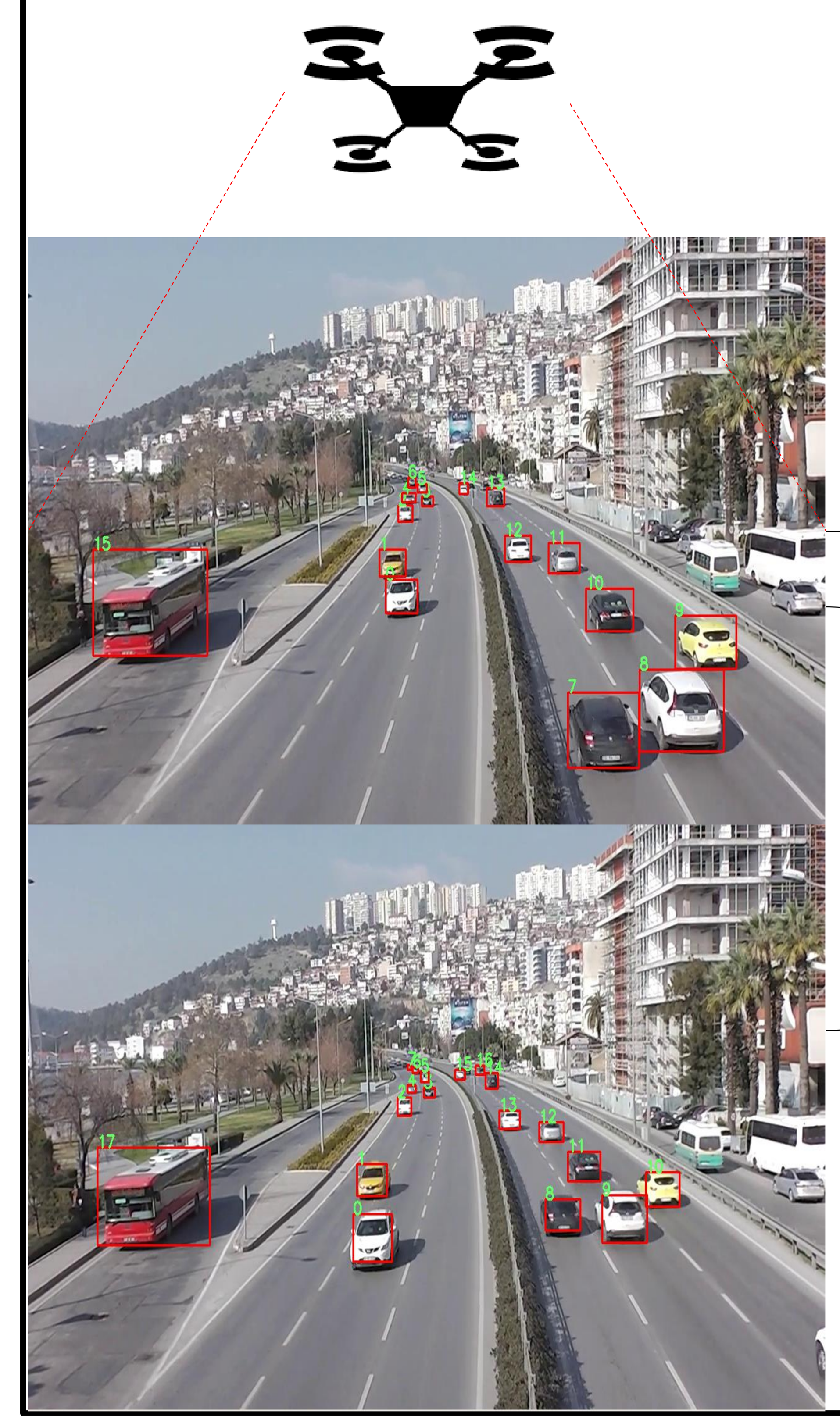
The Laplace transformation of the dynamics of the interconnected system is presented by

$$Z_i(s) = \frac{(s+q_1)}{(s + \frac{(q_1+q_4)}{(1+q_3)})}$$

If $\boldsymbol{q_1}, \boldsymbol{q_2}, \boldsymbol{q_3}$ are carefully chosen such that $q_1 q_3 > q_4$, SS follows immediately.

EXPERIMENTAL RESULTS

Aerial drone with real-time CV detection.



JSON database.

{"./frames/0.jpg":
[[[656, 316], [636, 338]],
 [[828, 326], [796, 353]],
[[613, 313], [631, 325]],
[[761, 302], [744, 314]]],
"./frames/1.jpg":
[[[827, 326], [797, 349]],
[[744, 313], [725, 325]]]
}

SS Calculation.

$$x_i$$

$$e_i$$

$$\frac{1}{(1+q_3)}[e_{(i-1)} + (q_1 + \lambda)e_{(i-1)} + q_1 \lambda e_{(i-1)}]$$

$$Z_i(s) = \frac{(s+q_1)}{(s + \frac{(q_1+q_4)}{(1+q_3)})}$$

Apply Constraint Satisfaction Heuristics to control platoon of vehicle.

REFERENCES

[1] String Stability of Interconnected Systems by D. Swaroop and J. K. Hedrick. IEEE Transactions On Automatic Control, Vol 41, No 3, March 1996.
[2] Stability of an Automated Vehicle Platoon. Yibing Wang and Zengjin Han. Proceedings of the American Control Conference, Philadelphia, Pennsylvania, June 1998.
[3] YOLO9000:Better, Faster, Stronger. Joseph Redmon and Ali Farhadi.

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