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Traffic Signal Control for a Burgers' Cellular Automaton Traffic Flow Model with Right and Left Turns Based on Particle Swarm Optimization

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Summary

Traffic jam is one of the most serious problem to be solved in the world, and it is caused by several reasons. We have focused on traffic signals installed at intersections, and it is expected that systematic traffic signal control yields reduction of traffic jam in comparison with traditional methods such as constant period control and traffic sensing control (Kai and Sato, 2020, 2021). First, we construct "a Burgers' cellular automaton traffic flow model with right and left turns" shown in Fig. 1, which is an ultradiscrete type of traffic flow models. The model has 4 intersections with traffic signals that can be controlled and indicate red or blue.

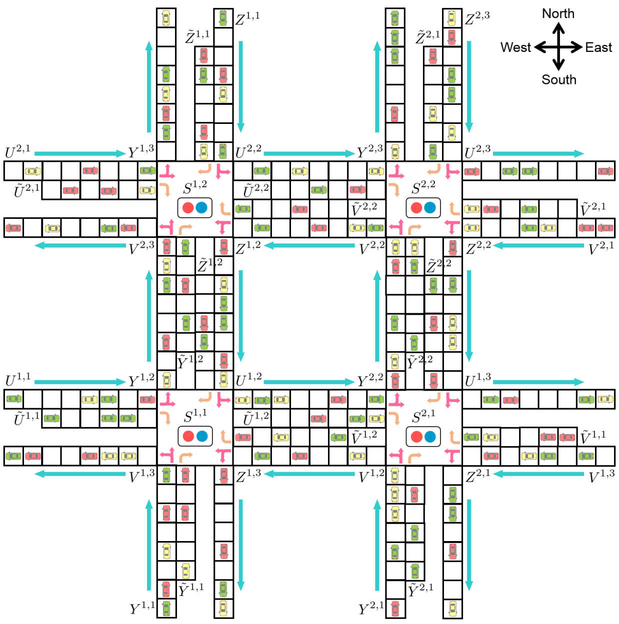

Figure 1: Burgers' Cellular Automaton Traffic Flow Model with Right and Left Turns

Next, a total number of traffic jam is defined for the traffic flow model, and we formulate an optimization problem to minimize it. However, it is represented as nonlinear integer programming problem and it is quite difficult to obtain the optimal solution. Thus, we show a solving method based on "particle swarm optimization (PSO)," which is one of the powerful heuristic methods to solve optimization problems. Moreover, in order to reduce computation amount, we also utilize "model predictive control (MPC)" that repeatedly solves optimization problems for short time interval.

In order to confirm the effectiveness of the proposed method, we perform numerical simulations. We use three methods for comparison; (a) time control: switch signals by 3 time steps, (b) comparing control: compare the two numbers of cars at the fronts of cells in a transverse and a longitudinal directions, then switch the signal at the cell whose numbers of cars is larger to blue, (c) PSO control: Switch signals by using the proposed control method based on PSO and MPC. 8 patterns of initial locations of cars and boundary conditions on inflow of cars to the model are generated at random, and numerical simulations are performed by using the control methods (a)–(c) for the 8 patterns.

Table 1 shows the total number of traffic jam obtained by the control methods (a)–(c) for the 8 patterns. From these averages, we can see that the proposed method (c) realizes about 48% reduction in comparison with (a), and (c) realizes about 41% reduction in comparison with (b). Consequently, it can be confirmed that the proposed signal control method via PSO and MPC is effective in terms of optimization and computation efficiency from the simulation results.

Table 1: Total Traffic Jams for Three Methods

No.	(a) Time	(b) Compare	(c) PSO
1	1034	879	474
2	1056	995	575
3	1416	1318	748
4	1253	922	577
5	1012	981	558
6	1167	1042	618
7	1072	921	556
8	1292	1102	693
Ave.	1162	1020	599