

Improved Information Feedback in Symmetric Dual-channel Traffic

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Abstract—Information feedback is very important in traffic systems. Real-time information feedback can improve traffic flow with existing facilities. This paper proposes a real-time information feedback strategy named improved mean number feedback strategy. Based on a two-route scenario, simulation results show that the strategy is much more effective in different length of roads or in different percentage of dynamic vehicles than the old strategies, i.e., congestion coefficient feedback strategy and mean velocity feedback strategy.

Keywords—information feedback; traffic flow; IMNFS

I. INTRODUCTION

Traffic flow has triggered great interest of researchers [1-3] in the past few decades because traffic problems has shown its effect on the society and attracted attention of people from almost all fields. It has grown as a problem that needs to be solved as soon as possible. Researches aiming at improving the ability of the existing traffic facilities have been done by some universities and institutes by now. Real time information feedback to guide vehicles' choices of routes has been proved to be effectively in improving the traffic situation. Wang etc. [3] proposed an advance real time information feedback in intelligent traffic systems in their paper. They proved that the congestion coefficient feedback strategy (CCFS) is better than travel time feedback strategy (TTFS) [4,5] and mean velocity feedback strategy (MVFS) [4] in a two-route scenario [6] with each single route following the cellular automaton model (CAM) proposed by Kai Nagel and Michael Schreckenberg [7]. CCFS [3] takes feedback time delay of TTFS into account and bring us a better feedback strategy than MVFS. However, it has not considered the effect of space delay. Sun etc. [8] has adopted CCFS in asymmetric two-route scenario while they did not change the nature of CCFS. In this paper, improved information feedback named improved mean number feedback strategy (IMNFS) taking the effect of space delay into account is presented. The simulation results adopting IMNFS and the other different feedback strategies such as MVFS, CCFS, ICCFS, IICCF, MNFS are reported.

The outline of this paper is as follows: in section II, the CAM and the two-route scenario will be introduced briefly, then CCFS together with the improved versions of it will be

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introduced, at last a completely new feedback strategy IMNFS together with MNFS will be introduced in detail. In section III, the simulation results of the different feedback strategies will be presented and some related discussions will be made based on the contrast of the results. In section IV, some conclusions will be made.

II. CAM AND INFORMATION FEEDBACK STRATEGIES

A. CAM

Cellular automaton model (CAM) [1,2] proposed by Kai Nagel and Michael Schreckenberg is a very useful and simple model in analyzing traffic flow. It was proposed as a one-dimension model. It can be used to simulate the traffic flow giving proper boundary conditions. Here, the mechanism of CAM will be introduced as a base simulation platform.

The road is divided into L sites. Each site may either be occupied by one vehicle or be empty. Each vehicle has a integer velocity v with values between 0 sites and v_{max} sites. The distance between a vehicle and the nearest vehicle ahead of it is d . To make contrast with the strategy proposed before, the parameters in this paper follow the values set in CCFS. Therefore, the length of a site is 7.5m and $v_{max} = 3$.

One update of the system consists of the following four consecutive steps, which are performed in parallel for all vehicles:

- 1) Acceleration: If $v \leq v_{max}$, then $v = v+1$;
- 2) Slowing down (due to other cars): If $d < v$, then $v = d$;
- 3) Randomization: with probability p , $v = v-1$;
- 4) Car motion: each vehicle is advanced by v sites.

The probability p takes account natural velocity fluctuations due to human behavior or varying external conditions.

B. Two-route scenario

The two-route scenario [6] is that there is symmetric dual-channel between the starting point and the destination. The dual-channel consists of route 1 and route 2 which are in the same direction and with the same length. At the entrance of the dual-channel is a board on which the feedback information is displayed. Vehicles arriving at the entrance can choose one of

routes to travel to the destination according to the real time information feedback. Again, the parameters and boundary conditions of the two routes are set the same as that in CCFS to contrast the effect of CCFS and the strategies proposed in this paper. In the simulations, set the same length of Route 1 and Route 2 L . At every time step, a new vehicle is generated at the entrance of the two routes. These vehicles can be divided into two types: dynamic ones and static ones. If a vehicle is dynamic, it will choose one of the two routes based on the information feedback. If a vehicle is static, it will randomly choose one route ignoring the information feedback. The proportion of dynamic ones is S_{dyn} . If a vehicle enters one route, it will update according to CAM. If a vehicle is not able to enter the desired route, it will wait for one time step and make a choice in the next time step. If a vehicle reaches the end of the two routes, it will be removed.

The simulations are performed by the following steps:

- 1) Initialization: set the routes and information feedback board empty;
- 2) Update: at every time step, the information feedback will be displayed on the information board. A vehicle will be generated in the entrance of the two routes and will choose one route either according to the board or randomly. All vehicles in the routes update following the CAM mechanism.
- 3) Calculation: the information feedback will be calculated in every time step. The traffic statistics will also be calculated to evaluate the traffic conditions.

The traffic conditions are characterized by flow of two routes. Adopting the definition of average flow F in one time step in CCFS,

$$F = V_{mean} \rho = V_{mean} \frac{N}{L}, \quad (1)$$

where V_{mean} represents the mean velocity of all vehicles on one road, N represents the total number of vehicles on one road, L is the length of the routes.

C. CCFS, ICCFS and IICCF

CCFS adopts the congestion coefficient C as feedback information.

$$C = \sum_{i=1}^m n_i^w, \quad (2)$$

where n_i represents the vehicle number of the i th congestion cluster in which vehicles are close to each other without a gap site between any two of them[3].

Although CCFS has been better than previous feedback strategies, it can be improved to be more effective. Fig. 1 shows a phenomenon when C of the two routes are the same but a rational vehicle will choose route2 for better instead of randomly choose one route in real traffic world.

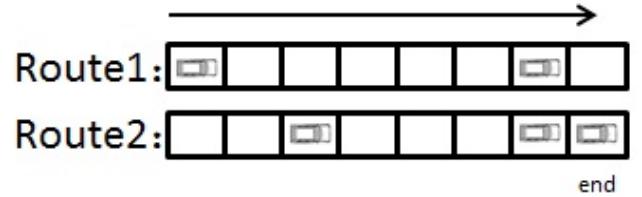


Fig. 1. Two routes with the same C in CCFS

The contradiction between CCFS and the real world indicates that CCFS has ignored the distance between the cluster and the entrance. The effect of a cluster varies according to the distance. To reflect the difference, this paper proposed ICCFS in which the congestion coefficient C is defined as follows,

$$C = \sum_{i=1}^m \frac{1}{d_i} n_i^w. \quad (3)$$

Another improved version IICCF is also proposed and the congestion coefficient C is defined as follows,

$$C = \sum_{i=1}^m \frac{1}{d_i(d_i+1)} n_i^w, \quad (4)$$

where d_i is the distance between the entrance and the first site of the i th cluster while the other parameters have definitions the same as in CCFS.

D. MNFS and IMNFS

In real traffic world, most vehicles choose a route by the number of cars on the roads or the density of vehicles on the roads. Therefore, this paper gives a simple mean number feedback strategy, in which the information feedback is defined as follows,

$$NF = \sum_{i=1}^L \frac{1}{L} n_i, \quad (5)$$

where NF is the mean number of roads, L is the length of the routes. $n_i = 1$ if site i is occupied by a vehicle otherwise, $n_i = 0$.

Obviously, MNFS has not considered the space delay which represents the different effects of sites from different distances. To improve MNFS, IMNFS is proposed here. In IMNFS, NF is defined as follows,

$$NF = \sum_{i=1}^L e_i n_i, \quad (6)$$

where e_i should satisfy two conditions as follows,

$$\begin{cases} \sum_{i=1}^L e_i = 1 \\ e_i > e_j (i < j) \end{cases}. \quad (7)$$

Therefore, a kind of e_i can be defined as follows,

$$e_i = \begin{cases} \frac{1}{i(i+1)} + \frac{1}{L+1} & (i=1) \\ \frac{1}{i(i+1)} & (i=2, 3, \dots, L) \end{cases} \quad (8)$$

Considering the space delay and real world situations, this paper improved CCFS and proposed ICCFS, IICCFCS and MNFS, IMNFS. In the next section, simulations adopting these feedback strategies together with MVFS will presented.

III. SIMULATION RESULTS

All simulation results in this paper are obtained by 10000 time steps excluding the initial 5000 time steps considering that the routes have reach an relatively stable state after the initial period. $S_{dyn}=0.5$, $L=2000$. In the simulation results, the average flow, vehicle number and average speed of the two routes in every time step will be calculated and shown in figures. TTFS has been proved to be instable and not as good as CCFS, this paper ignores TTFS. First, the results of average flow F

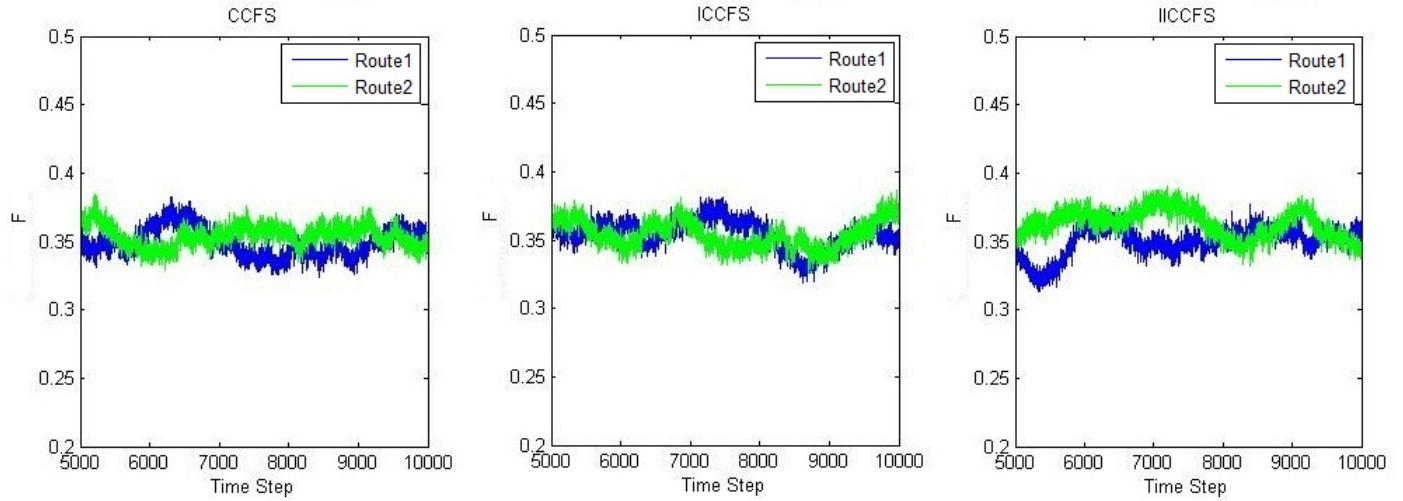


Fig. 2. The average flow F of CCFS, ICCFS and IICCFCS

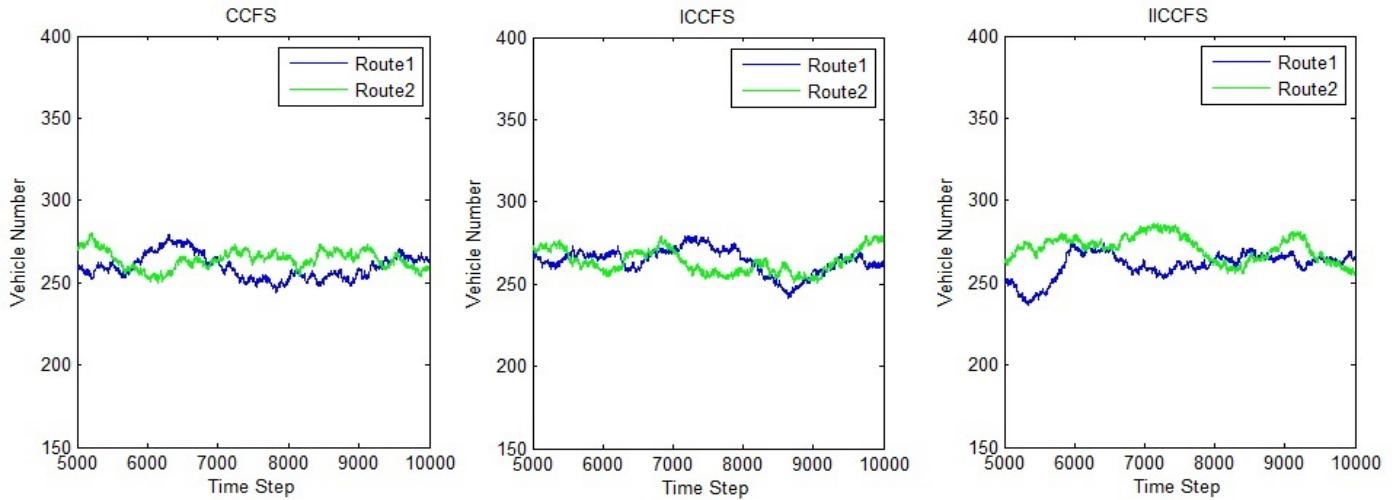


Fig. 3. The vehicle number of CCFS, ICCFS and IICCFCS

adopting CCFS, ICCFS, IICCFCS are shown in Fig. 2. The results of vehicle number are shown in Fig. 3 while the results of average speed are shown in Fig. 4. Contrasting the three figures, we can see that there are slightly differences. To be more clearly, Table I is given to show the total average flow of the three feedback strategies. Table I shows that IICCFCS is just a little better than ICCFS and ICCFS is just a little better than CCFS. The results trigger us to try another feedback strategy that can improve the traffic situation obviously.

TABLE I. AVERAGE FLOW F OF CCFS, ICCFS AND IICCFCS

Strategy	Average flow F		
	Route1	Route2	Total
CCFS	0.3493	0.3543	0.3518
ICCFS	0.3544	0.3538	0.3541
IICCFCS	0.3503	0.3633	0.3568

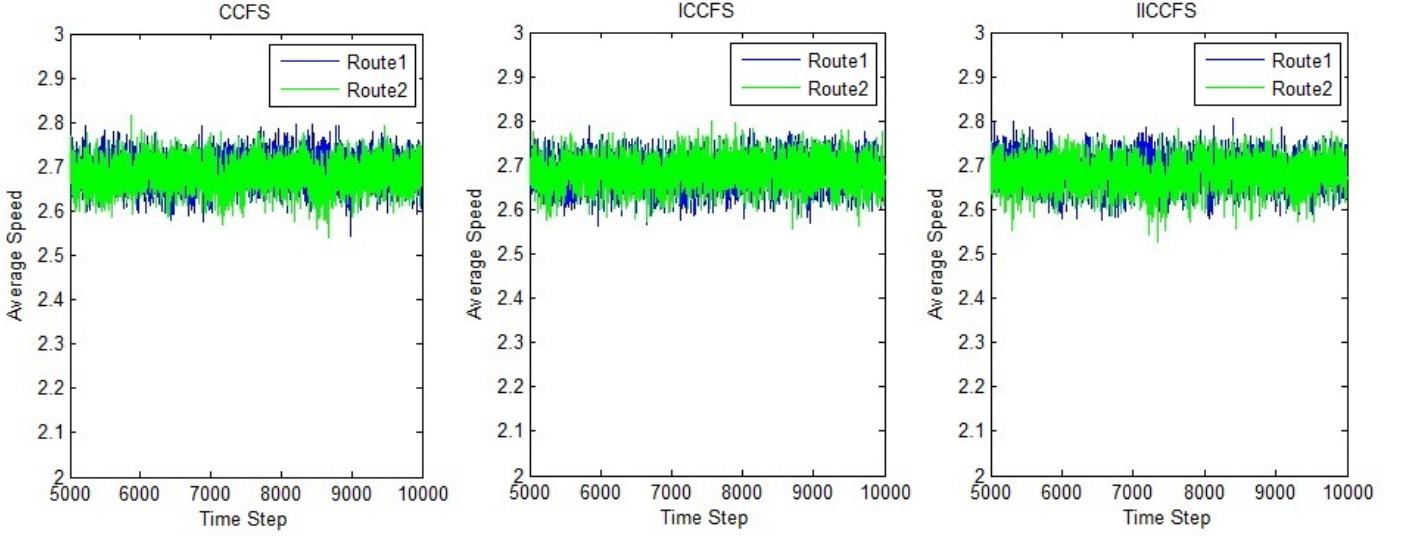


Fig. 4. The average speed of CCFS, ICCFS and IICCFSS

From the results shown above, we can see that the improved versions of CCFS are not satisfying. Therefore MNFS and IMNFS are tried, the simulation results are shown in Fig. 5, Fig. 6 and fig. 7. Fig. 5 shows that IMNFS is obviously better than the other two strategies while MNFS is a little better than CCFS. Fig. 6 and Fig. 7 show that the improvement of IMNFS is mainly because of the number of vehicles. Table II is given to show how much the improvement is.

TABLE II. AVERAGE FLOW F OF CCFS, MNFS AND IMNFS

Strategy	Average flow F		
	Route1	Route2	Total
CCFS	0.3493	0.3543	0.3518
MNFS	0.3644	0.3644	0.3644
IMNFS	0.4018	0.4029	0.4024

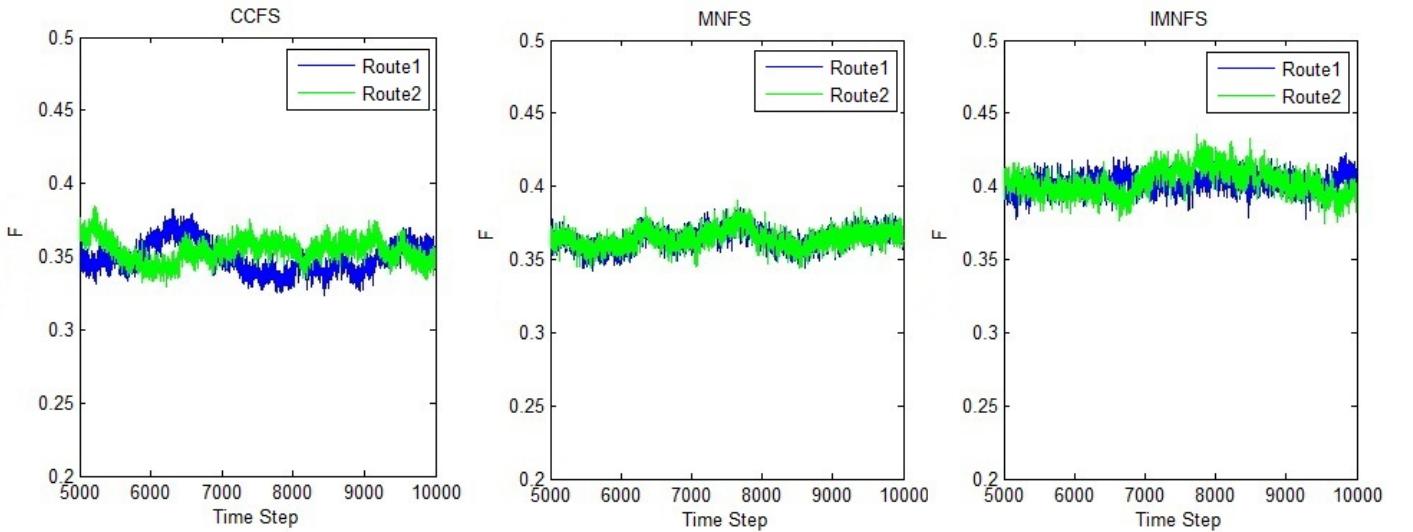


Fig. 5. The average flow F of CCFS, MNFS and IMNFS

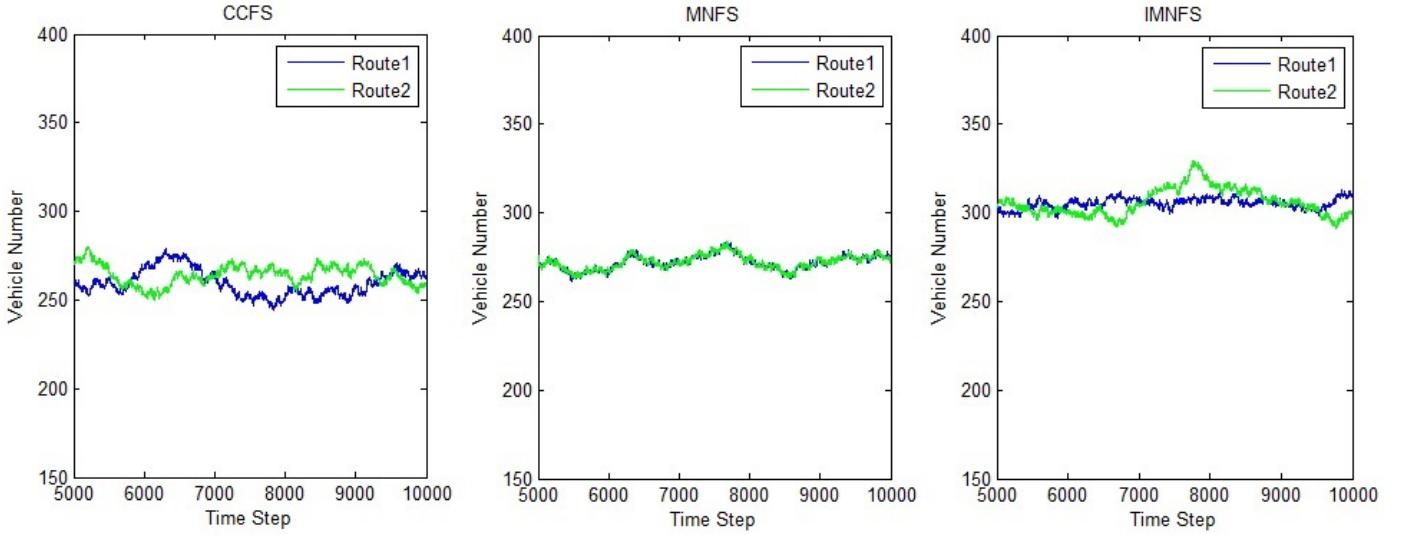


Fig. 6. The vehicle number of CCFS, MNFS and IMNFS

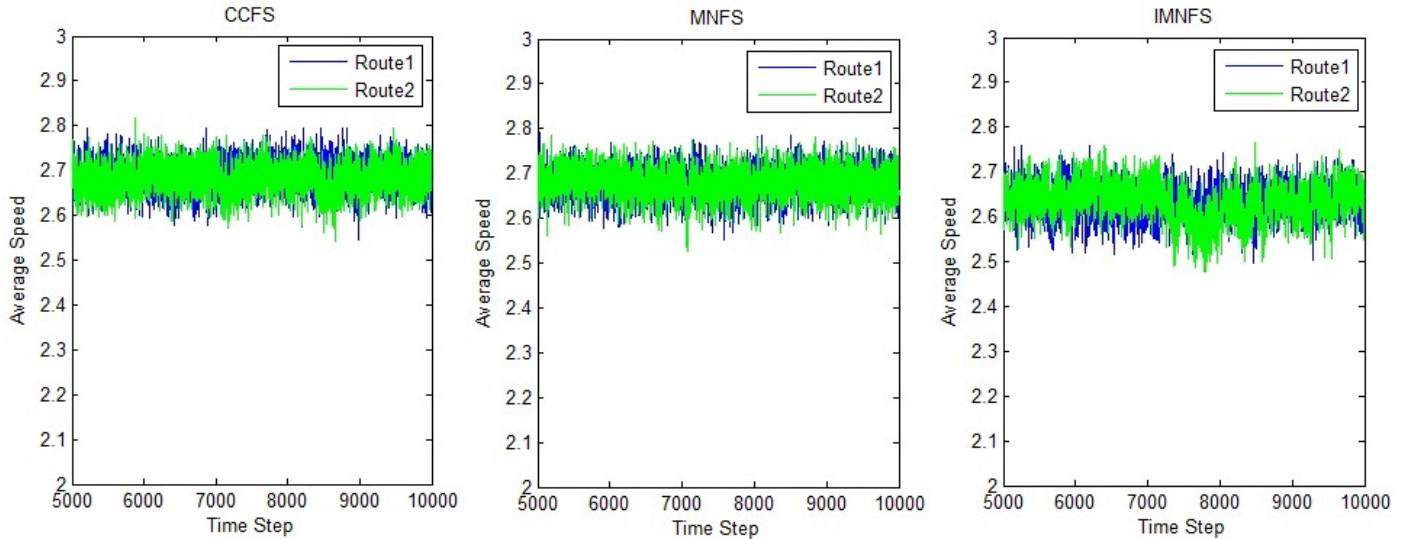


Fig. 7. The average speed of CCFS, MNFS and IMNFS

From all the simulation results shown above, IMNFS is the most effective strategy. To test whether IMNFS can keep the best strategy if the proportion of dynamic vehicles changes or the length of the route changes, this paper gives the simulation results when S_{dyn} varies from 0 to 1 in Fig. 8 and when L varies from 100 to 5000 in Fig. 9. Fig. 8 shows that with the increase of S_{dyn} , IMNFS keeps the best one among these strategies. The average flow of IMNFS and MNFS increases along with S_{dyn} while the other strategies keep the same level of average flow or go down a little. Fig. 9 shows that IMNFS is the best strategy when L changes.

IV. CONCLUSION

This paper proposed two improved versions of CCFS and two other feedback strategies MNFS and IMNFS. Through

simulations of different strategies, IMNFS shows the most effective feedback strategy in two-route scenario. IMNFS has considered space delay on a road and keep the best strategy when the dynamic vehicles percentage changes or the length of the route changes. In contrast with CCFS and MVFS proposed before this paper, IMNFS has more advantages. Therefore IMNFS is a meaningful improved information feedback in intelligent traffic systems.

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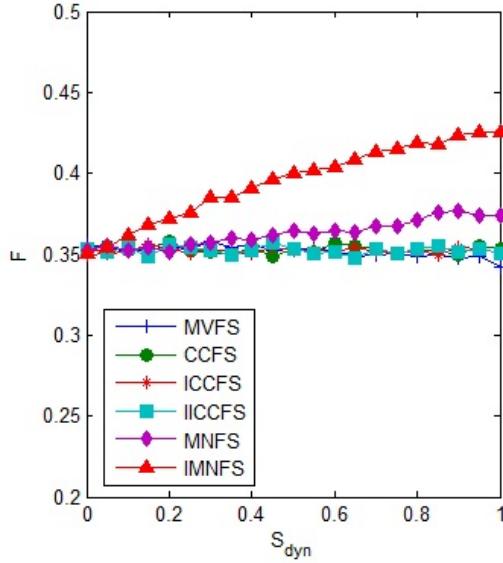


Fig. 8. The average flow F by performing different strategies vs. S_{dyn} ; $L=2000$.

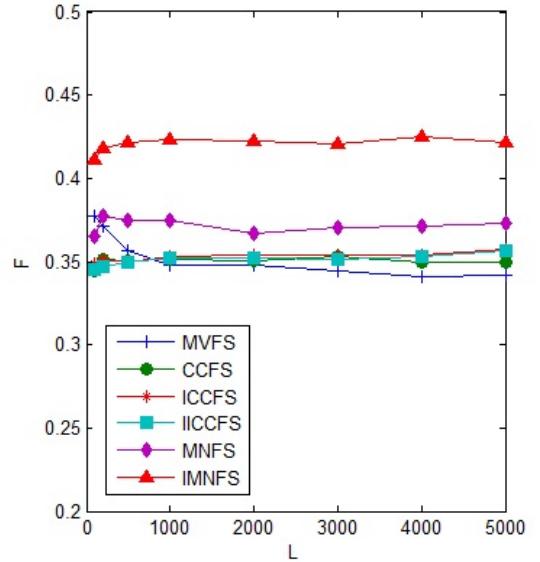


Fig. 9. The average flow F by performing different strategies vs. L ; $S_{dyn}=0.9$.

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