Application of adaptive weights to intelligent information systems: An intelligent transportation system as a case study

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A B S T R A C T

Optimization of information feedback technologies is very important for many socioeconomic systems such as stock markets and traffic systems aiming to make full use of resources. In this paper, we propose an adaptive weight method, which has potential value for a variety of information processing contexts. We apply this adaptive weight method to an intelligent transportation system (ITS) as a case study. A feedback strategy named Improved Congestion Coefficient Feedback Strategy (ICCFS) is introduced based on a two-route scenario in which dynamic information can be generated and displayed on the roadside in order to enable drivers to make an informed route decision. Our model incorporates the effects of adaptability into the cellular automaton models of traffic flow. Simulations demonstrate that adopting this optimal information feedback strategy provides a high efficiency in controlling spatial distribution of traffic patterns when compared with the three other information feedback strategies, i.e., Travel Time Feedback Strategy (TTFS), Mean Velocity Feedback Strategy (MVFS) and Congestion Coefficient Feedback Strategy (CCFS).

1. Introduction

For some socioeconomic systems, it is desirable to provide real-time information or even a short-term forecast about dynamics. For instance, in stock markets it is advantageous to give a reliable forecast in order to maximize profit. In traffic flow, advanced traveler information systems (ATIS) provide real-time information about the traffic conditions to road users by means of communication such as variable message signs, radio broadcasts, or on-board computers [1,13]. The aim is to help individual road users to minimize their personal travel time. Therefore traffic congestion should be alleviated, and the capacity of the existing infrastructure could be used more efficiently. Fig. 1 shows a schematic diagram of an information feedback system, illustrating that feedback information plays a significant role in the loop. We propose an adaptive weight method, which is potentially of value in a variety of information processing contexts. Here, we apply this adaptive weight method to an intelligent transportation system (ITS) as a case study.

With the development of information sciences, traffic flow and related problems become more and more important in the modern world. Researchers from many different disciplines (mathematics, physics and engineering) have targeted this problem, often using sophisticated mathematical tools brought from their own area of expertise [6–8,10,12,14,18,20]. Till now, a lot of different theories have been proposed, such as car-following theory [24], kinetic theory [11,22,23] and particle-hopping theory [4,5,21]. These theories may help scientists to gain understanding of vehicular systems. Therefore these theories

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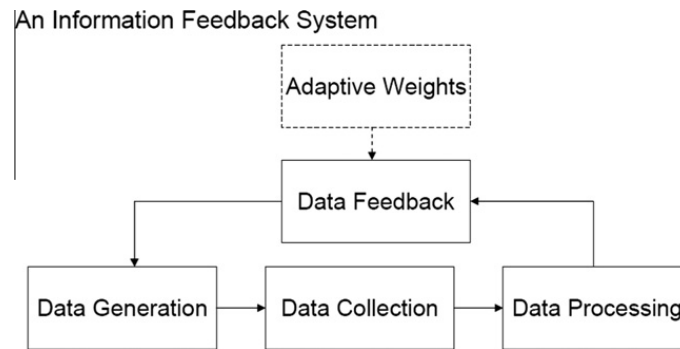 E-mail address: dcfy@umich.edu (C. Dong).

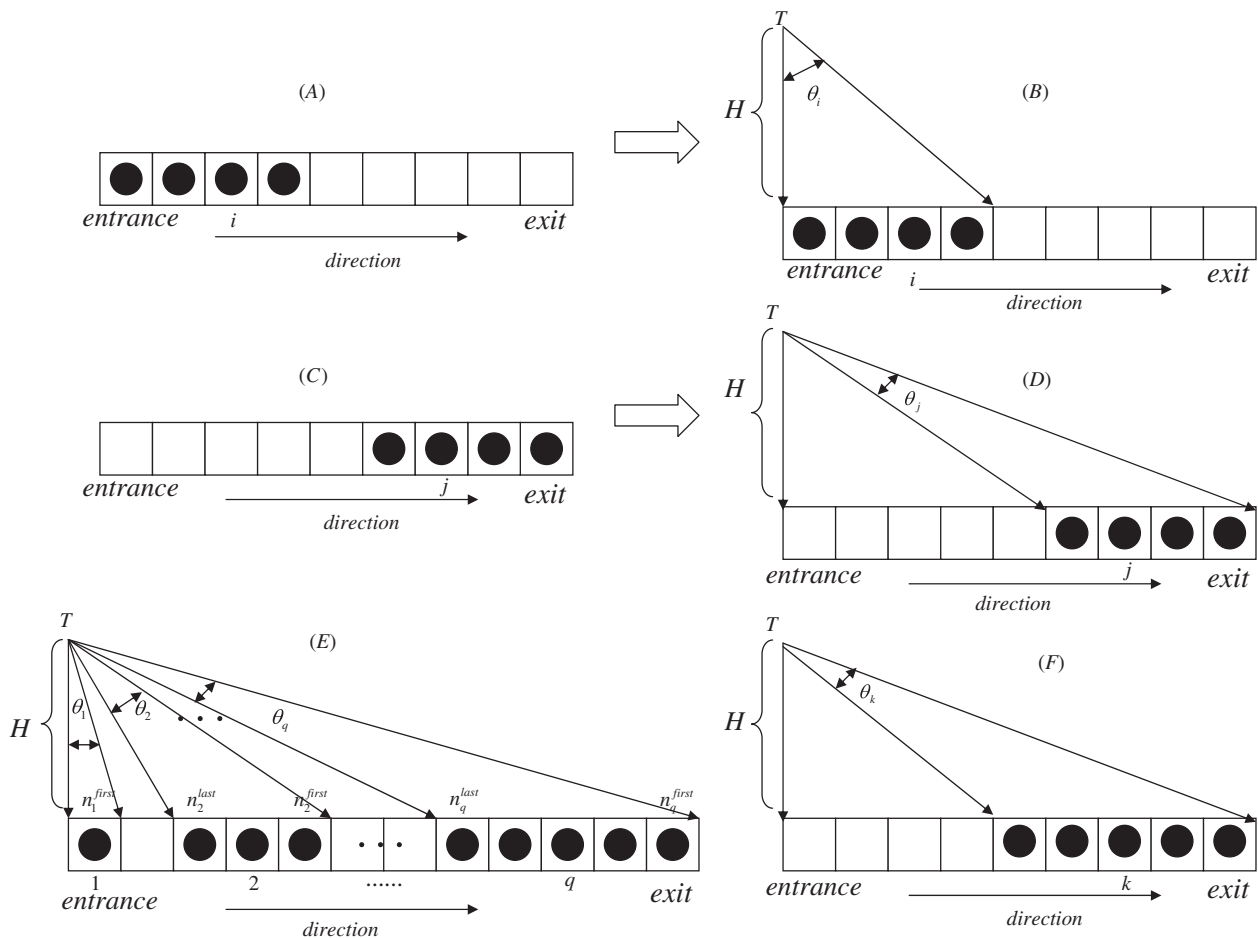**Fig. 1.** The schematic diagram of an information feedback system.

Fig. 2. The illustrations of routes without and with adaptive weights.

indirectly make contributions to alleviating traffic congestion and enhancing the capacity of existing infrastructure. Real-time traffic information plays a significant role in several applications of intelligent transportation system (ITS), such as advanced traffic management systems (ATMS) and advanced traveler information system (ATIS), etc. The traffic information collected can support traffic management administrators in making decisions, taking appropriate actions to alleviate congestion, and improving the global performance of traffic networks. Furthermore, since real-time traffic information can help drivers plan the trip before travelling and decide on the route to take to reduce travel time and improve travel safety, it is one of the most important features.

To date, a vast number of different dynamical model of traffic flow with real-time traffic information have been constructed [2,3,9,15,19,28], but proposing a more efficient feedback strategy is still an overall task. Wahle et al. [25,26] first investigated the two-route scenario with Travel Time Feedback Strategy (TTFS). Subsequently, Lee et al. [17] studied the effect of a different type of information feedback (Mean Velocity Feedback Strategy-MVFS), i.e., instantaneous average velocity. Wang et al. [27] proposed a third type of information feedback (Congestion Coefficient Feedback Strategy-CCFS), i.e.,

instantaneous congestion coefficient which is defined as $C = \sum_{i=1}^{q} n_i^2$. Here, n_i stands for vehicle number of the ith congestion cluster in which cars are close to each other without a gap between any two of them; q is the number of congestion clusters. It has been proved that TTFS is the worst one since this strategy brings a lag effect, making it impossible to provide road users with the real-time situation of each route [17]; CCFS is more efficient than MVFS because the random brake mechanism of the Nagel–Schreckenberg (NS) model [21] brings about fragile stability of velocity [27]. However, CCFS can still be improved due to the fact that it does not take route positions of the congestion clusters into consideration. For example, CCFS will be invalid under the situations shown in Fig. 2(A) and (C). More details will be explained in the following sections. We can use the schematic diagram without the dashed box (see Fig. 1) to describe the feedback procedure such as TTFS, MVFS, and CCFS. In order to provide road users with better guidance, a strategy named Improved Congestion Coefficient Feedback Strategy (ICCFS) is presented which is based on an adaptive weight method. The new feedback strategy can be described as the schematic diagram with the dashed box. We report the simulation results of adopting four different feedback strategies in a two-route scenario with a single route following the NS mechanism.

The remainder of this paper is given as follows: In Section 2, we briefly introduce the NS model and a two-route scenario proposed by Wahle et al. [25]. Also four feedback strategies: TTFS, MVFS, CCFS, and ICCFS will be mentioned. In Section 3, the simulation results will be presented and discussed based on the comparison of four different feedback strategies. In the last section, we will make some conclusions.

2. The model and feedback strategies

2.1. NS mechanism and two-route scenario

Till now, the Nagel–Schreckenberg (NS) model is still the most popular cellular automaton (CA) model due to the fact that it is the simplest CA model in analyzing the traffic flow, and it can reproduce the basic features of real traffic like stop-and-go wave, phantom jams, and the phase transition on a fundamental diagram that plots vehicle flow versus density [7,12,20,21]. We will briefly introduce NS mechanism in the following paragraphs.

The road is subdivided into cells (sites) with a length of $\Delta x = 7.5$ m. We set the length of the route to be $L = 2000$ cells (corresponding to 15 km). Let N be the total number of vehicles on a single route of length L; the vehicle density is $\rho = N/L$. A time step corresponds to $\Delta t = 1$ s, the typical time a driver needs to react. $g_i(t)$ is defined as the number of empty sites in front of the ith vehicle at time t, and $v_i(t)$ denotes the speed of the ith vehicle. In the NS model, the maximum speed is fixed at $v_{max} = M$. In the present paper, we set $M = 3$ cells/time step (corresponding to 81 km/h and thus a reasonable value) for simplicity.

The Nagel–Schreckenberg (NS) model is briefly introduced as follows which can be divided into the following four rules [21]:

R1: Acceleration:

$$v_i(t) \rightarrow v_i\left(t + \frac{1}{3}\right) = min[v_i(t) + 1, v_{max}];$$

R2: Deceleration:

$$v_i\left(t + \frac{1}{3}\right) \rightarrow v_i\left(t + \frac{2}{3}\right) = min\left[v_i\left(t + \frac{1}{3}\right), g_i(t)\right];$$

R3: Random brake:

$$v_i\left(t + \frac{2}{3}\right) \rightarrow v_i(t + 1) = max\left[0, v_i\left(t + \frac{2}{3}\right) - 1\right];$$

with a certain brake probability p;

R4: Movement:

$$x_i(t + 1) = x_i(t) + v_i(t + 1).$$

Recently, Wahle et al. [25] investigated a two-route model. In their model, a percentage of drivers (referred to as dynamic drivers) choose one of the two routes according to the real-time information displayed on the roadside. In their model, the two routes A and B are of the same length L. Every time step, a new vehicle will be generated at the entrance of the traffic system. If a driver is a so-called static one, he enters a route at random ignoring any advice. The density of dynamic and static travelers are S_{dyn} and $1 - S_{dyn}$, respectively. Once a vehicle enters one of two routes, the motion of it will follow the dynamics of the NS model. In our simulation, a vehicle will be removed after it reaches the end point. It is important to note that if a vehicle cannot enter the preferred route, it will wait till the next time step rather than entering the un-preferred route.

The simulations are performed by the following steps: first, we set the routes and board empty; second, after the vehicles enter the routes, according to four different feedback strategies, information will be generated, transmitted, and displayed on

the board at each time step. Finally, the dynamic road users will choose the route with better conditions according to the dynamic information at the entrance of two routes. Here, we should point out that we initially set the routes and boards empty and let vehicles enter the routes randomly during the initial 100 time steps in the simulation. Thus, the feedback starts at the 101th second on the basis of the initial route state. In simulations, vehicles can enter the preferred route only when the first 3 sites of the route are empty in order to avoiding collisions.

2.2. Related definitions

The road conditions can be characterized by fluxes of two routes, and flux is defined as follows:

$$F = V_{mean}\rho = V_{mean}\frac{N}{L}, \tag{2.1}$$

where V_{mean} represents the mean velocity of all the vehicles on one of the roads, N denotes the vehicle number on each road, and L is the length of the routes. In this paper, the physical sense of flux F is the number of vehicles passing the exit of the traffic system each time step. Therefore the larger the value F is, the better processing capacity the traffic system has. Then we describe four different feedback strategies as follows:

TTFS: Initially, both routes are empty. The information of travel time on the board is set to be zero. The traffic control center will record the time when a vehicle enters and leaves the traffic system, and display how long the vehicle takes to pass the route on the roadside. The new dynamic driver will choose the road with shorter time.

MVFS: Every time step, the velocity of each vehicle will be known from navigation system (GPS). The traffic control center will calculate the mean velocity of each route and display it on the roadside. Road users at the entrance will choose one road with larger mean velocity.

CCFS: The position of each vehicle will be known by the signal transmitted from navigation system (GPS). The traffic control center will compute the congestion coefficient of each route based on these information and display it on the roadside. Road users at the entrance will choose one road with smaller congestion coefficient. The congestion coefficient is defined as

$$C = \sum_{i=1}^{q} n_i^w. \tag{2.2}$$

Here, n_i stands for vehicle number of the ith congestion cluster in which cars are close to each other without a gap between any two of them, and q denotes the total number of congestion clusters on one route. Every cluster is evaluated by a weight w, where $w = 2$ (one can check out that $w > 2$ leads to the similar results with $w = 2$) [27]. The reason for adding weight to each cluster can be explained by the fact that travel time of the last vehicle of the cluster from the entrance to the destination is obviously affected by the size of cluster. With the increasing of cluster size, travel time of the last vehicle will be longer, and the correlation between cluster size and travel time of the last vehicle is nonlinear. For simplicity, an exponent w is added to the size of each cluster to be consistent with the nonlinear relationship. However, CCFS will be invalid when the same length of clusters exist on each route (see Fig. 2 (A) and (C)) since congestion coefficients C are the same under these two situations. This is due to the fact that CCFS does not take the route positions of the clusters into account. It indicates that weights should be added on different parts of the route besides each cluster. In other words, the weights should take both the route position and the length of each cluster into account. For example, if we add the corresponding angle of each cluster as a part of feedback information as shown in Fig. 2 (B) and (D), the problem can be solved easily. Hence a new information feedback strategy that takes this factor into consideration may improve the road capacity. In this paper, we propose a new feedback strategy named ICCFS that described as follows:

ICCFS: Every time step, the traffic control center will receive data from the navigation system (GPS) as CCFS. The work of the center is to compute the congestion coefficient of each road with a reasonable weighted coefficient and display it on the roadside. Road users at the entrance will choose one road with smaller weighted congestion coefficient. The weighted congestion coefficient is defined as follows:

$$C_\theta = \sum_{i=1}^{q} \theta_i n_i^2 = \sum_{i=1}^{q} \left(\arctan\left(\frac{n_i^{first}}{H}\right) - \arctan\left(\frac{n_i^{first} - l_i}{H}\right) \right) n_i^2,$$

$$\theta_i \in \left(0, \frac{\pi}{2}\right); \quad \theta = \sum_{i=1}^{q} \theta_i \leqslant \frac{\pi}{2}, \tag{2.3}$$

where n_i stands for vehicle number of the ith congestion cluster in which vehicles are close to each other without a gap between any two of them, n_i^{first} denotes the position of the first vehicle in the ith congestion cluster (see Fig. 2(E)), and l_i is the length of the ith congestion cluster. It is clear that $\theta_i = \arctan\left(\frac{n_i^{first}}{H}\right) - \arctan\left(\frac{n_i^{first} - l_i}{H}\right)$ is the weighted coefficient. It plays a significant role in improving the road capacity which will be explained in the following paragraphs. q denotes the total number of congestion clusters on one route. After we tried a lot of different positions of the point T, the location of T above the first lane site was selected since it provided the largest average flux for each lane. This can also be understood, and we will
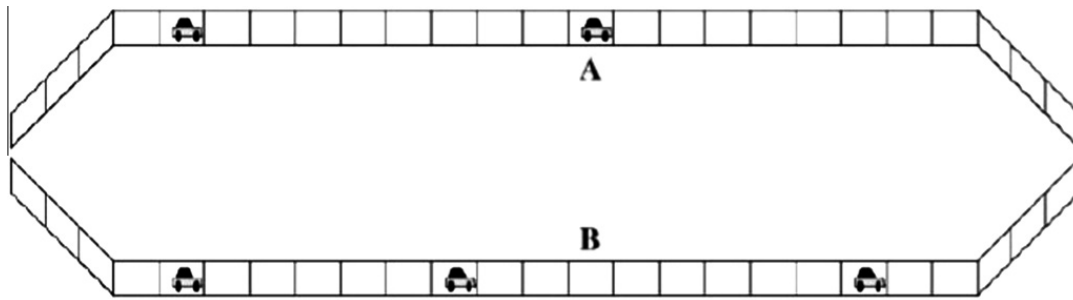
Fig. 3. The one entrance and one exit two-route traffic system.

explain the reason in the next section. The normalized formula of Eq. (2.3) can be written as $C_\phi = \sum_{i=1}^q \phi_i n_i^2$, where $\phi_i = \frac{\theta_i}{(\pi/2)} \in (0,1)$ and $\phi = \sum_{i=1}^q \phi_i$, thus $\phi \leqslant 1$. The normalized form of Eq. (2.3) might be better understood and could be generalized to other applications, however, the results adopting these two different forms of Eq. (2.3) are necessarily the same in this paper.

Fig. 3 illustrates the "one entrance and one exit" structure of the traffic system. In reality, there are different paths for drivers to choose from one place to another place. In this paper, we focus on a two-route system. Different drivers departing from the same place could choose two different paths to get to the same destination which corresponds to the "one entrance and one exit" system. Thus the road condition in present work is close to reality. The rules at the exit of the two-route system are as follows:

(a) The special velocity update mechanism for the vehicle nearest to the exit:
  (i) velocity (t) = Min (velocity (t) + 1, 3), (probability: 75%);
  (ii) velocity (t) = Max (velocity (t) − 1, 0), (probability: 25%);
(b) Rules at the exit when vehicles competing for driving out:
  (i) At the end of two routes, the vehicle nearer to the exit goes first.
  (ii) If the vehicles at the end of two routes have the same distance to the exit, the faster a vehicle drives, the sooner it goes out.
  (iii) If the vehicles at the end of two routes have the same speed and distance to the exit, the vehicle in the route containing more vehicles drives out first.
  (iv) If the rules (i), (ii) and (iii) are satisfied at the same time, then the vehicles go out randomly.
(c) velocity (t) = position (t)-position ($t − 1$), where position (t) = L = 2000; (valid only for the vehicles failed in competing for driving out at exit);

Here we want to stress that the vehicle nearest to the exit will not obey the NS mechanism but the special mechanism as shown in rule (a). However, vehicles following the vehicle closest to the exit still obey the NS mechanism. One should also be aware that if the vehicle nearest to the exit does not compete with the vehicle on the other route for driving out or wins in the competition, the vehicle will ignore rule (c). The special velocity update mechanism (rule (a)) is equivalent to the situation that 75% drivers exhibit aggressive behavior and 25% drivers exhibit timid behavior near the exit, which is similar to the recent work studied by Laval and Leclercq [16]. Please note that drivers exhibit timid behavior may also exhibit aggressive behavior at next time step otherwise the timid drivers may stop at the exit all the time. In the following section, performance by using four different feedback strategies will be shown and discussed in detail.

3. Simulation results

All simulation results shown here are obtained by 15000 iterations excluding the initial 10000 time steps. Given that the average flux is instable during the first 10000 time steps, we exclude the initial 10000 time steps. Fig. 4 shows the dependence of average flux on vertical distance H (see Fig. 2) by using the new feedback strategy. H is the vertical distance from point T to the route. H is a very important quantity, because it can adjust the relative weight values among different cells on one route. For example, if point T locates above the first route cell and H is very small, weight value of the first cell can even be much larger than that of the second cell. Also, if point T locates above the first route cell and H is infinity, there will be nearly no difference between different cells on the weight value. As to the routes' processing capacity, we can see that in Fig. 4 there is a positive peak structure at the vicinity of $H \sim 440$. Thus the vertical distance H is fixed at 440 in the following paragraphs. The weighted congestion coefficient C_θ (see Eq. (2.3)) depends on both the position and the length of each congestion cluster on the route, while the former congestion coefficient C (see Eq. (2.2)) only depends on the length of the congestion cluster. The location of point T as shown in Fig. 2 makes the weight of the entrance larger than that of the exit when adopting ICCFS. There are several reasons for this application. First, road users use the information on the roadside at the entrance of the traffic system to decide which route to enter. This will directly affect the road conditions. In other words,
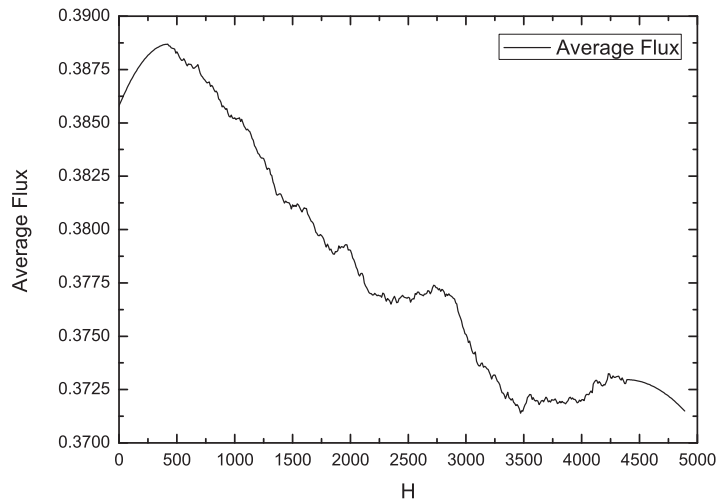
Fig. 4. Average flux *vs* vertical distance (*H*). The parameters are $L = 2000$, $p = 0.25$, and $S_{dyn} = 0.5$.
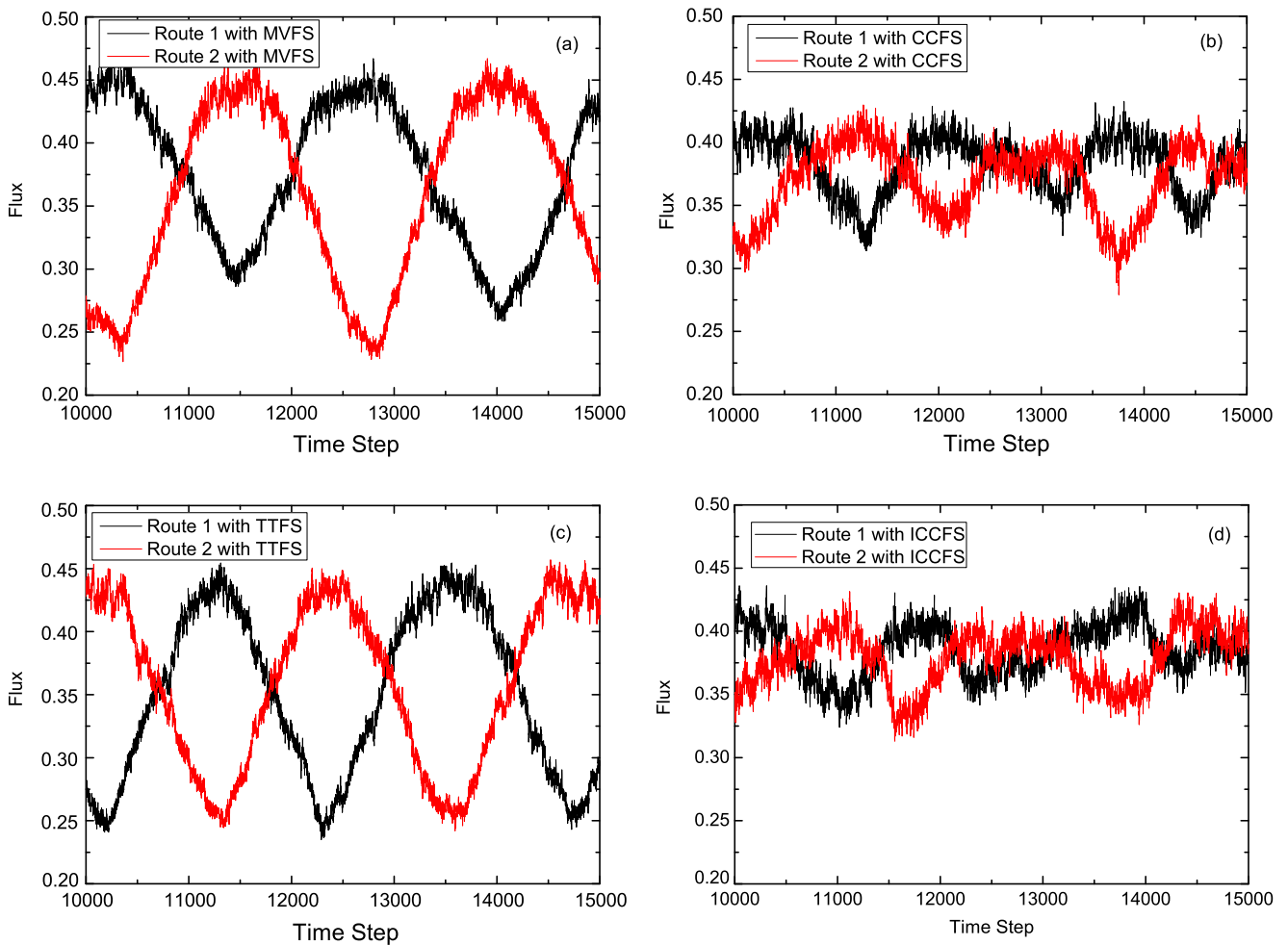

Fig. 5. (a) Flux of each route with mean velocity feedback strategy. (b) Flux of each route with congestion coefficient feedback strategy. (c) Flux of each route with travel time feedback strategy. (d) Flux of each route with improved congestion coefficient feedback strategy. The parameters are $L = 2000$, $p = 0.25$, $S_{dyn} = 0.5$, and vertical distance (*H*) is fixed at 440.

vehicles tend to be more affected by local traffic conditions than by conditions far ahead on the roadway. For instance, vehicles entering the route with a larger weighted congestion coefficient will definitely cause the road conditions to be worse
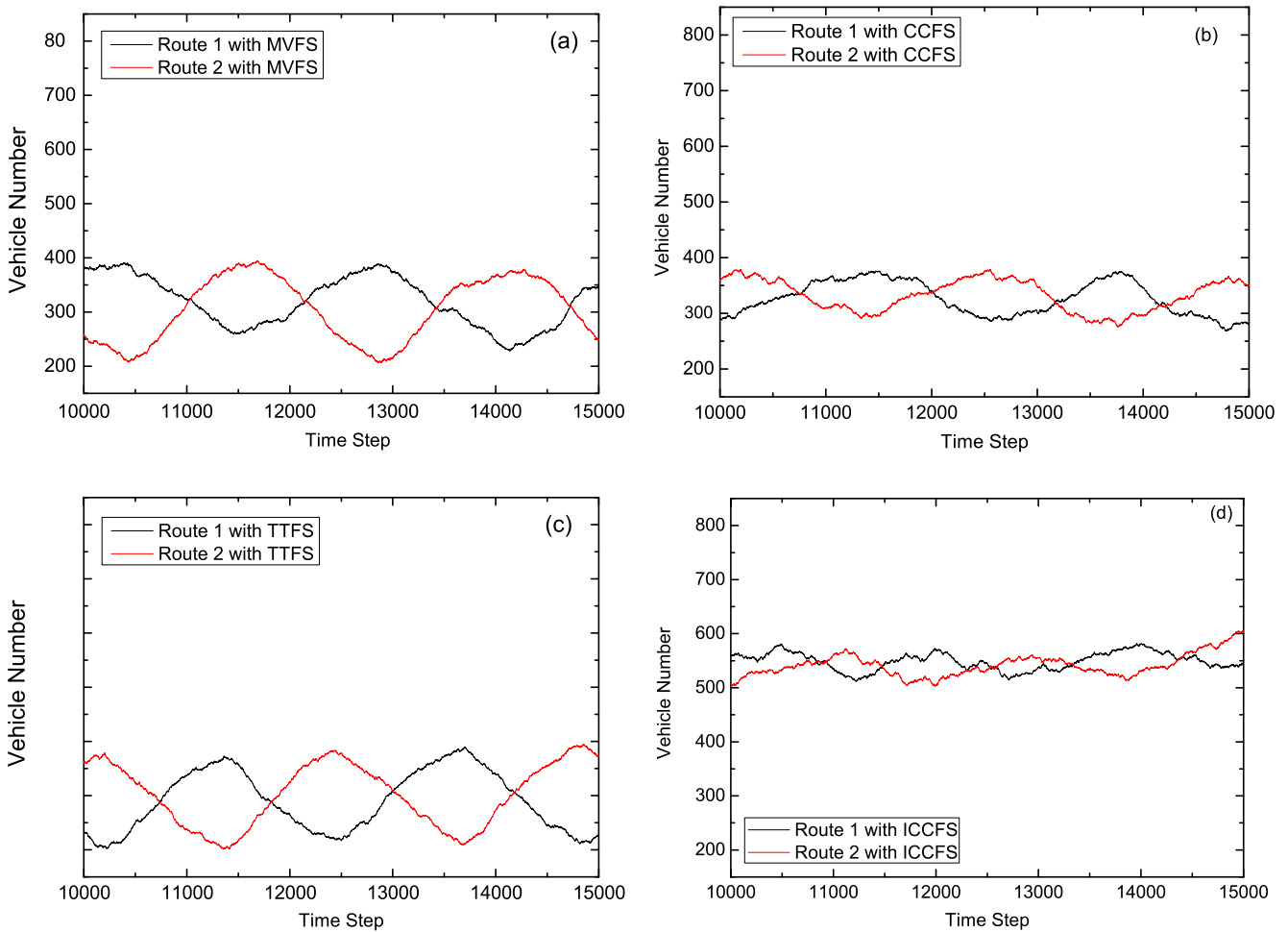
Fig. 6. (a) Vehicle number of each route with mean velocity feedback strategy. (b) Vehicle number of each route with congestion coefficient feedback strategy. (c) Vehicle number of each route with travel time feedback strategy. (d) Vehicle number of each route with improved congestion coefficient feedback strategy. The parameters are set the same as in Fig. 5.

than before (see Fig. 2(B) and (D)). Second, the small weight value at the end of the route will alleviate the negative effects of congestion caused by the traffic jam which will be explained in the next few paragraphs.

In contrast with ICCFS, the fluxes of two routes adopting TTFS, MVFS, and CCFS show larger oscillation (see Fig. 5). Oscillation is caused by the fact that all vehicles at the entrance keep entering one of the routes during a period of time, which causes the flux of one route to become very high while the flux of the other route becomes very low. Obviously, oscillation of flux values is not a desirable phenomena for it indicates that the flux is unstable in terms of one route, though the average flux is stable with regard to the whole traffic system because of the information feedback. It is clearly shown in Fig. 8 that the larger the oscillation of flux, the lower the value of average flux because the strategies with oscillations indicate vehicles cannot make full use of the whole traffic system. Therefore the strategies with oscillations should be improved or replaced with another better feedback strategy.

The oscillations shown in Fig. 5 can be understood since the other three strategies do not take the route position of the cluster into account. Furthermore, the oscillation may also be due to the information lag effect. For TTFS, the travel time reported by a driver at the end of three routes only represents the road condition in front of him, and perhaps the vehicles behind him have gotten into the jammed state. Unfortunately, this information will induce more vehicles to choose this route until a vehicle from the jammed cluster leaves the system. This effect apparently does harm to the system. For MVFS, we have mentioned that the NS model has a random brake scenario which causes the fragile stability of velocity, so MVFS cannot completely reflect the real condition of routes. The other reason for the disadvantage of MVFS is that flux consists of two parts, mean velocity and vehicle density, but MVFS only grasps one part and lacks the other part of flux.

Additionally, given the one exit structure and the special velocity update mechanism for the vehicle nearest to the exit, at most one car can go out at each time step. This may result in the traffic jam happening at the end of the routes. However, the new strategy can make the value of the congestion coefficient at the end of the routes smaller as shown in Fig. 2 which is equivalent to alleviating the negative effects of congestion caused by the traffic jam. Meanwhile, the new strategy also takes the length of the congestion cluster into account, which gives the road users better guidance because the larger congestion cluster length will partially result in larger C_θ (see Fig. 2(D) and (F)). Under the situation shown in Fig. 2(D) and (F), the road
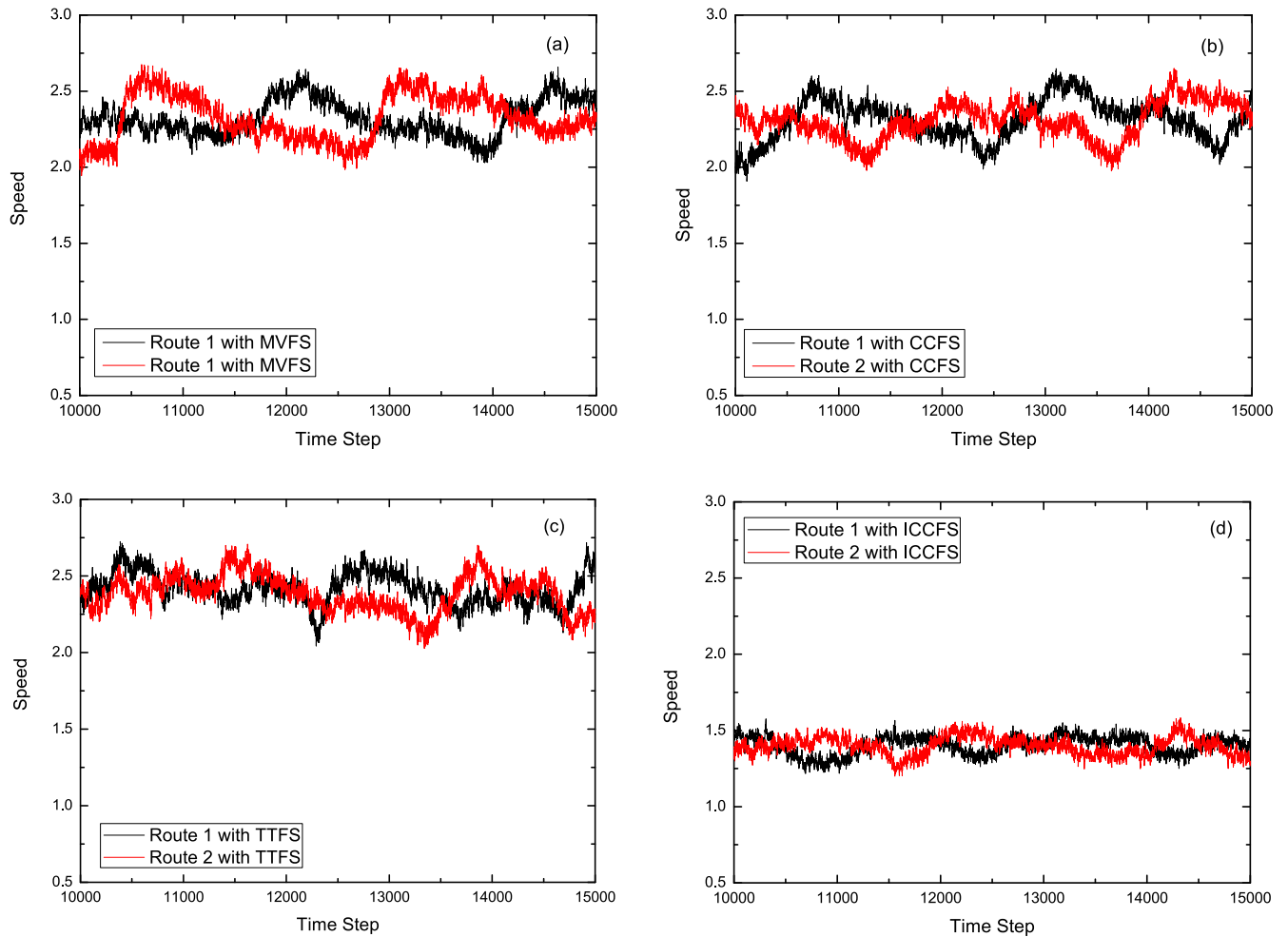
Fig. 7. (a) Average speed of each route with mean velocity feedback strategy. (b) Average speed of each route with congestion coefficient feedback strategy. (c) Average speed of each route with travel time feedback strategy. (d) Average speed of each route with improved congestion coefficient feedback strategy. The parameters are set the same as in Fig. 5.
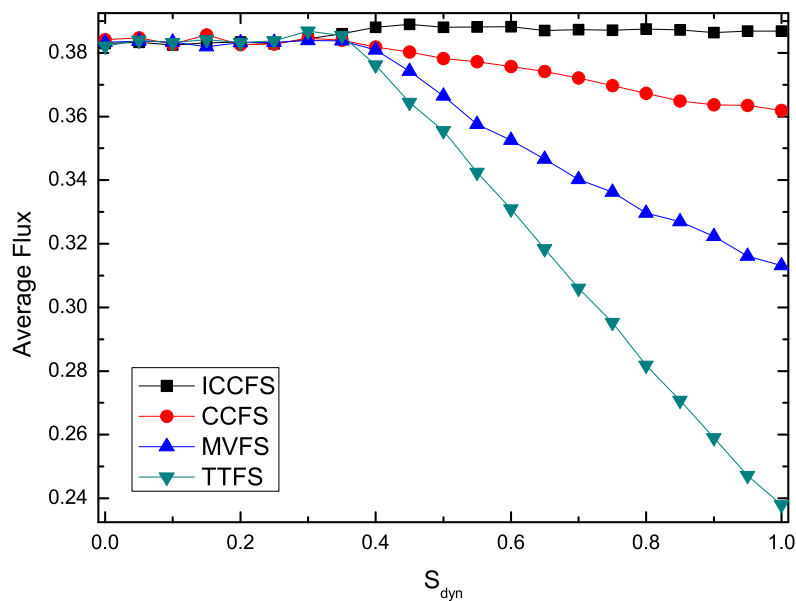

Fig. 8. Average flux by performing different strategy *vs* S_{dyn}; *L* is fixed at 2000, *p* is fixed at 0.25 and vertical distance (*H*) is fixed at 440.
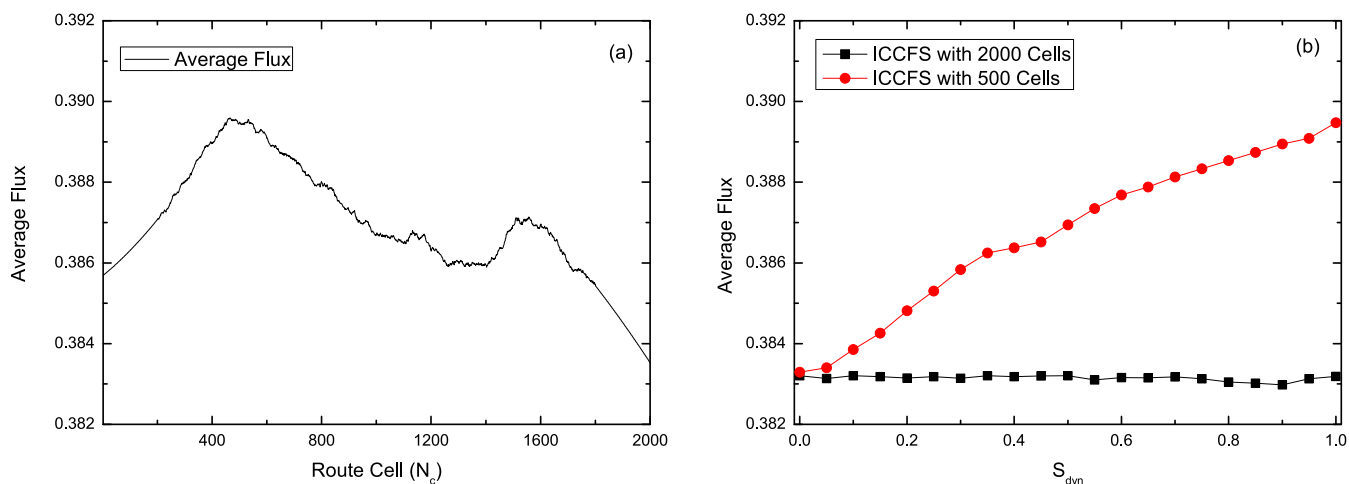
Fig. 9. (a) Average flux *vs* route cells contributed to feedback (N_{cell}) in one entrance and one exit traffic systems. The parameters are $L = 2000$, $p = 0.25$, and $S_{dyn} = 1.0$. (b) Average flux by performing ICCFS with different feedback route length *vs* S_{dyn} in one entrance and one exit traffic systems; L is fixed at 2000, p is fixed at 0.25 and the route cell numbers contributed to feedback are fixed at 2000 and 500, respectively.
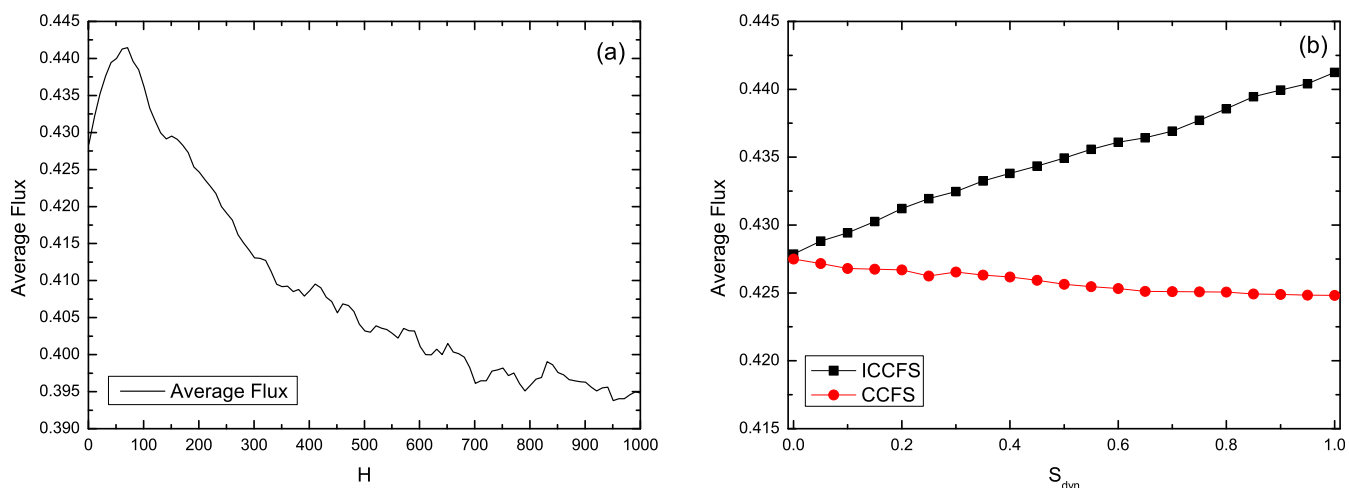

Fig. 10. (a) Average flux *vs* vertical distance (H) in one entrance and two exits traffic systems. The parameters are $L = 2000$, $p = 0.25$, and $S_{dyn} = 1.0$. (b) Average flux by performing different feedback strategies *vs* S_{dyn} in one entrance and two exits traffic systems; L is fixed at 2000, p is fixed at 0.25 and vertical distance (H) is fixed at 70.

users will choose route (D) instead of route (F) according to the value of C_0. Hence the new strategy not only maintains the advantages of CCFS but also takes route positions of the congestion clusters into account. Compared to CCFS, the performance adopting ICCFS is remarkably improved, not only on the value but also the stability of the flux. Therefore with respect to the flux of the two-route system, ICCFS is the optimal one.

In Fig. 6, the dependence of vehicle number on time step shows the similar tendency as Fig. 5. The vehicle number by adopting ICCFS is much larger than that adopting the rest three strategies, so perhaps the high fluxes of two routes with ICCFS are mainly due to the increase of vehicle number. From the stability of the vehicle number on each lane, we see that the vehicles should be uniformly distributed on each route instead of being together at the end of the routes.

In Fig. 7, the relationship between speed and time step shows that the speed is the stablest by using the new feedback strategy; however, it is the lowest among the four different strategies. Due to the one exit structure and the special velocity update mechanism for the vehicle nearest to the exit, at most one car can go out at each time step. Given the routes' accommodating capacity is the most efficient by using the new strategy, the more cars the lane owns, the lower speeds the vehicles have. Fortunately, flux consists of two parts, mean velocity and vehicle density. Hence as long as the vehicle number (because the vehicle density is $\rho = N/L$, and the length L is fixed at 2000 such that $\rho \propto$ vehicle number (N)) is large enough, the flux can also be the largest.

Fig. 8 shows that the dependence of the average flux on a persisting increase of dynamic travelers by using four different strategies. The new strategy is proved to be the best one because the flux is always the largest at each S_{dyn} value and keeps the two routes' fluxes in balance. The fact that the values of average fluxes in Fig. 8 adopting the other three strategies are

smaller than those shown in Ref. [27] comes from the different structures of the traffic system that has only one exit and the special velocity update mechanism for the vehicle nearest to the exit.

Finally, we investigate the effects of taking partial route information as feedback. Fig. 9(a) illustrates that the dependence of average flux on the number of feedback route cells (N_{cell}) by adopting ICCFS. For instance, if N_{cell} = 100, it means

$$C_\theta = \begin{cases} \sum_{i=1}^{q} \left(\arctan\left(\frac{n_i^{first}}{H}\right) - \arctan\left(\frac{n_i^{first}-l_i}{H}\right) \right) n_i^2, & \text{if } N_{cell} \leqslant 100, \\ 0, & \text{if } N_{cell} > 100. \end{cases}$$

From Fig. 9(a), we know that there is a positive peak structure at the vicinity of $N_{cell} \sim 500$. Therefore if we take the first 500 route cells as the feedback route length, it should work best. Fig. 9(b) shows the relationship between average flux and the density of dynamic travelers (S_{dyn}) by using ICCFS with different feedback route length. The results shown by Fig. 9(b) are in accordance with the results illustrated by Fig. 9(a); the average flux is significantly improved by taking partial route information as feedback. This demonstrates again that vehicles tend to be more affected by local traffic conditions than by conditions far ahead on the roadway. Meanwhile, it will cost less and be more efficient by calculating the partial route information as feedback.

4. Conclusion

We simulate the dependence of the flux, number of vehicles, and speed on time step by using four information feedback strategies, i.e., TTFS, MVFS, CCFS, and ICCFS in a two-route scenario. Further, we obtain the results of average flux versus S_{dyn}, average flux versus N_{cell}, and average flux versus vertical distance (H) by using ICCFS in both the one-exit and two-exit traffic systems (detailed below). The results indicate that ICCFS is better than the rest three information feedback strategies in both the one-exit and two-exit traffic systems. ICCFS can greatly improve road conditions compared with the other three feedback strategies, such as enhancing average flux with the increase of S_{dyn}, increasing flux and vehicle number, and reducing oscillation. It can be understood because the new strategy can reflect the weights of different parts of the route and take the length of each congestion cluster into consideration as well. Also, the new strategy can alleviate the negative effects of congestion caused by the traffic jam at the end of the route. The numerical simulations demonstrate that the vertical distance, H, plays a very important role in improving the road situation, because H can adjust the relative weight value of different cells on one route as explained before. Moreover, we also investigate the effects of taking partial route information as feedback. Simulations show that when we take the first 500 route cells information as feedback, it works the best.

With the development of science and technology, we believe that ICCFS can be applied to real-time traffic system soon. Once installing a navigation system (GPS) in each vehicle, the locations of vehicles will be known. ICCFS can be realized via computational simulation by adding the adaptive weight value on each congestion cluster on the basis of CCFS. The cost of ICCFS is similar with that of CCFS because the computers used to compute the weighted congestion coefficient can also calculate the corresponding angle. Further, if we adopt the partial route information as feedback, i.e., the initial 500 route cells, it will become more efficient. We believe this new feedback strategy will be applicable due to its concision and high efficiency.

Lastly, we want to stress that the adaptive weight method is suitable to a lot of information feedback systems. As long as the information feedback needs to take the distance-based information into account, the adaptive weight method will work. The location of point T and length of vertical distance H depend on the specific problem. For example, Fig. 10(a) shows the dependence of average flux on vertical distance (H) in a one entrance and two exits traffic system. Given that the entrance of the traffic system plays an important role as explained in the previous paragraphs, we still fix the location of point T above the first route cell. As to the routes' processing capacity, we can see that in Fig. 10(a) there is a positive peak structure at the vicinity of $H \sim 70$. Fig. 10(b) shows that the average flux fluctuates feebly with a persisting increase of dynamic travelers by using two different strategies in a one entrance and two exits traffic system. As to the routes' processing capacity, the new strategy, ICCFS, is proved to be better than CCFS due to the fact that average flux increases with the increase of S_{dyn}. Also, selecting of large or small feedback value also depends on the specific problem, e.g., if the feedback information is profit related information, we definitely should select the largest one. Even when the information systems are time-based systems such as stock markets, this adaptive method also works. Under this situation, the corresponding angle should depend on the different time points instead of different route cells. Finally, whether we should take the whole system or partial system information as feedback also depends on the specific problem.

Acknowledgments

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