A NEW APPROACH TO SOLVE CROSSWALK PROBLEMS

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Recently problems of traffic coordination and management on a network of streets were not so urgent. Networks of streets functioned efficiently enough in moderate load conditions, and their activities do not cause significant missing and denial of service. Increase of motorization and transport mobility of the population has led to the saturation of urban streets in recent years, which led to the revaluation of traffic management principles [1].

Statistical data of the movement intensity on main streets of the United States and Europe have shown that major traffic flows are focusing on arterial highways, in other words, the principle of "the concentration concept" carries out [2], which calls significant interest in improving traffic management on urban roads and main streets. The annual increase in traffic load on the arterial highways is leading to steady decline in traffic flow speed and formation of congestions.

Use of traffic-light signaling provides an opportunity for alternate passage of vehicles and pedestrians. Typically, traffic light control mode is calculated on the basis of conflicting traffic flow volumes and then needs of pedestrians are checked.
The time required for passage of pedestrians on any specific direction, is calculated by empirical formula [3], which is widely spread in the world and takes into account the total time required to let pass pedestrians

$$tpd=5+B/Vpd, \tag{1}$$

where tpd is duration of cycle regulation, providing passage of pedestrians, B is the length of a crosswalk to an opposite sidewalk or a street-refuge, Vpd is speed of pedestrian movement (usually is taken as 1.3 m/sec).

Two-phase cycle is usually applied at controlled crosswalks, which are located on arterial links. Its value Tc is determined by taking into account the time of pedestrian "patient waiting" (30 sec):

$$Tc = 35 + B / Vpd. \tag{2}$$

Then the cycle time for a vehicle passing is defined as:

$$tvh= T_c-(5+B/ Vpd)- ti1- t_{i2}, \tag{3}$$

where ti1 and ti2 are lengths of intermediate cycles.

If duration of the intermediate cycle is taken as 3 s, then the time for passage of vehicles is 24 sec subject to the formula (3). This time is not always sufficient at high intensity traffic.

However, it is considered that the interests of traffic safety are provided, as the maximum waiting time for pedestrians does not exceed the time of "patient waiting".

Recently, the interests of pedestrians has been diminished due to congestion growth caused by heavy traffic, and often "patient waiting" time is increased in 1,5-2 times. Digital displays with reverse report time are set to mitigate the precedent. Nevertheless, nobody can undo psychologically tuned "patient waiting" time. As a result, some pedestrians break rules of road and expose themselves and drivers of motor vehicles to undue risk.

Thus there is an adjustable crosswalk crossing six lanes and contains a traffic light cycle of 55 seconds of prohibiting signal for pedestrians and 25 seconds of allowing signal in Minsk on Pobeditelej Avenue at the Sport Palace. Thus "patient waiting" time is increased by 55-30 = 25 seconds. Preservation of "patient waiting" parameters with heavy traffic on this highway would bring to more frequent (almost 2 times) interruption of traffic movement, which would lead to increased losses in traffic movement. Fuel loss calculation for traffic flow interrupting is shown below. The losses are very substantial.

Economic factor is the obvious point in the conflict with a pedestrian and a vehicle. So abrupt stop of a vehicle at a crosswalk leads to fuel loss, which is equal to the kinetic energy, which this vehicle had before the stop.

Let a platoon of vehicles consists of the following cars: 16 passenger cars, 3 trucks, 2 buses. After a stop at the intersection the platoon should restore its previous speed of 60 km / h and, consequently, the previous kinetic energy is:

$$w=mv^2/2. \tag{4}$$

Let us choose the following model masses of the transport to calculate the kinetic energy [4]:

– A passenger car (on average for VAZ-2108) - 1450 kg;

– A truck (on average for GAZ-5312) - 7850 kg;

– A bus (on average for LiAZ-677M) - 16,133 kg.
Consequently, the total weight of the platoon is 1450 * 1916 7850 * 3 + 16133 * 2 = 79016 kg.
W = 79016 * 16 * 16 / 2 = 10.91 MJ is the necessary energy for starting up to the original speed before the intersection. The amount of fuel spent for starting, can be determined by dividing the amount of the found energy by the specific combustion heat of fuel (gasoline). Specific combustion heat of gasoline is 47 MJ / kg.

Thus, the amount of wasted fuel is 10.91/47 = 0.23 (kg). Since the engine coefficient of efficiency is 25% then four times more fuel is required to accelerate, videlicet, 0.92 kg or 1.31 liters.

The calculation shows that 1,3 liters of fuel are lost on the average each cycle of a traffic light. Cycle duration of a traffic light on the average is 1.5 min, therefore, fuel overrun is 52.4 liters.

Pedestrian flows are obstacle not just on links, but also at an intersection for left (right) side transport. Congestions appear as a result of insufficient duration of green phase of traffic lights and large number of left (right) side transport. Thus, the percentage contribution of pedestrians in the creation of congestions is not less than 1 / 3.

At present we know two options to remove pedestrians as an obstacle for vehicles. These options propose to take out pedestrian crossings over or under the highway. The first option spoils architectural view of a city and prevents trolleybus lines. The second option is very expensive. In this paper we propose a radical solution to the problem of pedestrians in traffic movement, which allows them almost to eliminate from the traffic movement.

Pedestrians should be moved from point N to point K (Fig. 1), in a way that does not affect the arterial traffic flow. To transfer a large amount of data in information theory, they are compacted, then encapsulated and transmitted. Let us apply a similar mechanism in the case of pedestrians who need to be grouped compactly (encapsulated) and moved quickly from point N to point K. For this purpose mobile pedestrian robot is proposed, which is included in traffic management system of a city.

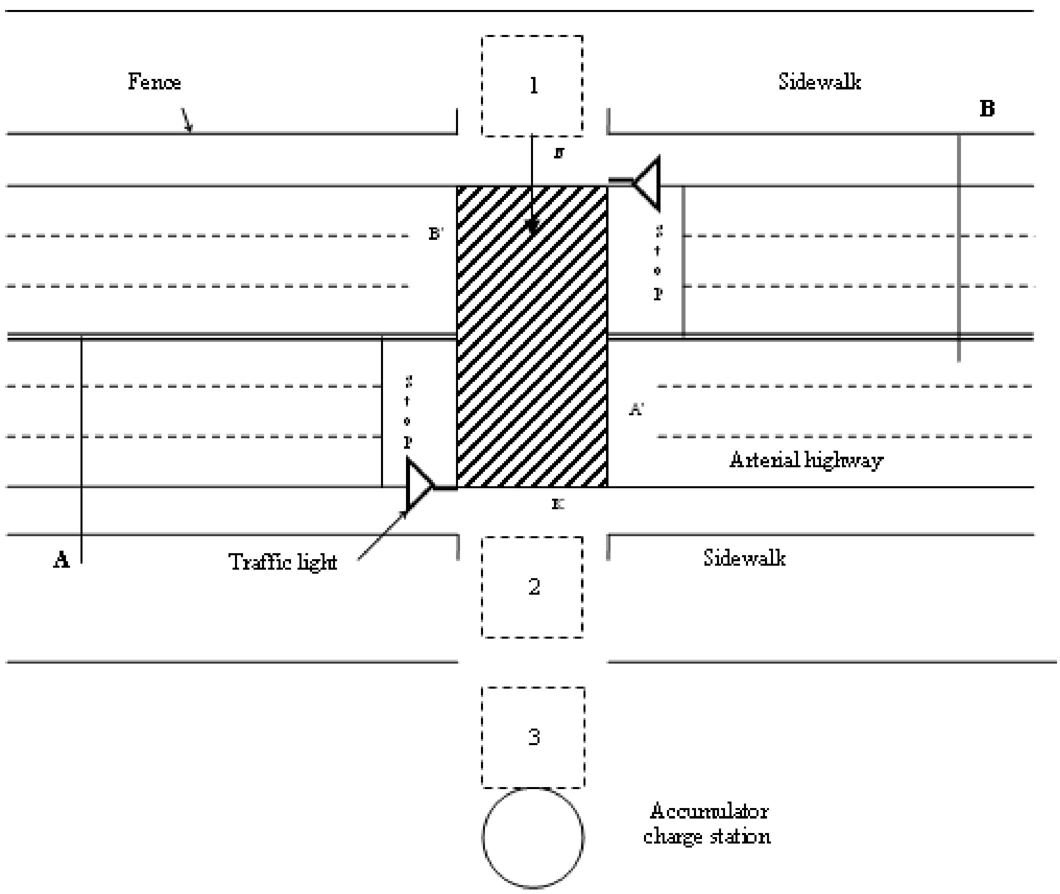

Figure1: A crosswalk on an arterial link

Mobile pedestrian robot is law-platform electric car without a driver, of sufficient capacity, with standing and holding the rail passengers. Controlling of the robot is performed by an internal, built-in computer.

Download in electric car cabin is made in positions 1 and 2 (Fig. 1). At this time the doors are opened and pedestrians come into the cabin. There are two pairs of infrared (IR) sensors with the numbers 1 and 2 at the entrance (the door) to determine the number of people in the electric car. When the pair of infrared sensors is crossed in the order of 1-2, one will be entering the electric car, when the order is 2-1, one will be leaving the cabin. Thus it is possible to see to the number of passengers in the cabin of the electric car. There will be no need to start movement without passengers even if the traffic control system gives the signal, which allows beginning of the motion.
The electric car cabin is filling during green phase of traffic lights on the arterial highway. The door of the electric car has been closed after two events: expiring of time t_{min} (the minimum duration of the main cycle) and the lack of incoming pedestrians shown by electric sensors of the door. Now the electric car is ready to move. Detectors, located in section A and B on the highway (Fig. 1) should give a signal at the beginning of the movement. There is a distance of 100 m between sections A, B and boundaries of the crosswalk A`, B`. A vehicle traveling at speed of v = 60 km / h crosses this distance over 6 seconds. This is so-called vehicle time t_{veh}. If the next car does not appear above the line A (B) through the time equal t_{veh}, then consequently, a gap has appeared in the traffic flow, which is not less in duration than t_{veh}. So there are no vehicles between lines AA' and BB' and the electric car can start moving without causing any obstacle on the arterial highway.

In this case red signal lights for vehicles on the arterial highway, and green signal lights for the electric car. The electric car will pass the crosswalk with length of 30 meters for 3 seconds at an average speed of 40 kilometers per hour. As soon as it is in the position 2, signals will immediately be changed.

Transportation of pedestrians has been performed without stopping vehicles on the arterial highway. The process of moving pedestrians from the position 2 to the position 1 performs similarly. (Fig. 1).
The eectric car does not run along the crosswalk permanently. Transport detectors measure the intensity of traffic flow in sections A and B. And if it fall below the specified value M_1, the electric car will move to the position 3 (Fig. 1). In this case, the crosswalk is used in traditional way. If the intensity increases up to a value M_2 ($M_2 > M_1$) and this value keeps within some specified time t_z, the electric car will drive out to the position 2 for the next load of pedestrians.

The electric car is in the position 3 at night, and also in the case of specified above low intensity of traffic flows. At this time it connects to a charging station.

Conclusion

An effective way of vehicle unhindered travel through controlled pedestrian crosswalks was offered, as well as through controlled intersections , where there will not be such an interference, as a pedestrian. Payback of the system is 3-6 months depending on the installation site.

Currently, a computer simulation of the system "Pedestrian Robot" has been performed in various modes of pedestrian and traffic intensity and, as well as a working model of the current system has been completed. The authors hope for joint development with such a authoritative company as Belkomunmash.

In addition, the authors express well-founded pessimism, because the country has very low commercialization of projects [5]. In America up to 30% of technologies reach commercial success, in the EU this number is 20%, and the number not more than 3% for the former Soviet Union countries. So the authors are ready to cooperate with the businessmen from all countries presented at this representative forum.

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