The study of the influence of intelligent driver assistance systems on the capacity of urban roads

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Abstract. The article gives theoretical and experimental studies of the time delay of cars in the stream, due to the time of the driver's reaction to changing traffic conditions. In the present study, it was switching of allowing signal of the traffic light which was assigned as the initial moment of the measurements. The observation showed the dependence of the delay time of the car on its position in the queue at the junction with traffic light regulation. Due to the presence of the human factor, the accumulated delay along the flow has had a great influence on the number of vehicles which had the opportunity to cross the junction within one traffic light cycle. A situation was simulated in which all vehicles in a stream were equipped with an assistant driver device when moving in a traffic jam. The value of the delay of the car when using electronics is 5.44 times less than the delay caused by the human factor. The study was conducted in a part of Nadezhda Suslova street in the city of Nizhny Novgorod and showed the possibility to increase the speed and intensity of the considered actual traffic flow.

Recently, there have been more and more news related to increasing relevance of unmanned vehicles. Large auto concerns are actively developing rob-mobiles (unmanned vehicles) and technologies for them. Questions about the prospects of the development of unmanned vehicles were raised in many scientific papers and conferences [3].

The development of unmanned vehicles is aimed at reducing the number of accidents, caused by some human factor, namely, fatigue, lack of attention and slow speed of the driver’s reaction. The reaction rate, as shown by many studies, is seriously affected by a large number of external and internal factors, such as bad weather conditions, the dark time of day, or driver’s fatigue. It is known that the reaction is the response of the body to an external irritant factor. Simple reactions include responses to a single irritant (for example, braking a vehicle in front of another car). More complicated - the action of several factors at once (for example, at an adjustable intersection, you have to watch the change of traffic signals and the movement of pedestrians crossing the roadway, as well as watch other vehicles). Various research show that the duration of the driver’s response to many stimuli is: for braking in front of a vehicle with a stop signal - 0.42 s, for traffic lights in a populated area - 0.40 s, for road signs-0.50 s, on the bumps on the road – 0.80 s.

The reaction time of the driver is a variable value, which depends on external and internal factors. In most cases, in order to take a person out of his mental equilibrium, a short enough impact is required, while the electronics and mechanical parts of the vehicle wear out gradually.
Currently, unmanned vehicles are not widely used, but in the automotive industry, intelligent driver assistance systems are often used. Some systems are designed to draw additional attention to the traffic situation, for example, by giving sound or light signals to the driver, some other- more modern are able to interfere to the process of driving. So, there is a question – to what extent intelligent driver assistance system are effective.

For the study, TrafficJamAssist was chosen (traffic assistant in traffic) as the most relevant system for urban traffic, especially during peak hours. The question was asked- to what extent it is possible to increase the speed and intensity of movement, if all the vehicles from the stream are equipped with an assistant in a traffic jam as compared to the existing traffic situation.

The considered intelligent system combines adaptive cruise control and lane assist, provides the beginning of the movement, smooth acceleration, steering, braking within the lane. Some variations of the system, such as on the AudiA8, have an algorithm of actions in a situation when the car is cut when driving close to the front of the car. This model uses the assumption that there is no need to keep your hands on the wheel, while at SKODA SuperbCombi this condition is obligatory. Also, for most models, due to the low level of optical equipment, it is necessary to have a good roadbed with clearly visible signs on the asphalt. After leaving the jam, the driver must take control. Otherwise, the system will issue several warnings, and then, without receiving a response from the driver, will smoothly stop the car.

In an experimental study, the main parameter was the delay time of the start of the vehicle movement, that is, the time elapsed from the moment of the beginning of the movement of the vehicle in front to the moment of the beginning of the next movement.

For an experimental study, a section of Nadezhda Suslova Street in the Sovetsky district of the city of Nizhny Novgorod was chosen in the area from the house 2-k1 to the intersection with Vaneev Street. The length of the plot is 410 meters, number of lanes: 1 lane in the direction from Vaneev street to Brinsky street, 2 lanes in the opposite direction. The time of measurement is from 7:30 to 8:30 in the morning, as the time of the greatest intensity of the city traffic flow.

![Figure 1. Study area (view of Yandex Map (as on 28.03.18))](image)

The start of the traffic light cycle was taken as the starting point of time in the stream. The calculations are based on the delay values for the first six vehicles in the queue at the traffic lights. The measurement results are presented in Table 1.
Figure 2. Study area on the Yandex Map (view from the satellite)

A detailed diagram of the considered section of the road with the indication of road signs and road markings is made in the AutoCAD 2007 program and is presented in Figure 3.

Figure 3. The scheme of the investigated section of the road in the environment of AutoCad, indicating road signs and road signals.

Table 1. Delay of the car, depending on its position in the queue, sec.

| № of measurement/auto № in the queue | 6  | 5  | 4  | 3  | 2  | 1  |
|-------------------------------------|----|----|----|----|----|----|
| 1                                   | 0.75 | 1.27 | 1.09 | 0.76 | 0.75 | -0.30 |
| 2                                   | 1.43 | 0.20 | 0.96 | 0.70 | 0.72 | -0.95 |
| 3                                   | 1.46 | 2.07 | 1.97 | 0.20 | 0.50 | -1.05 |
| 4                                   | 1.25 | 1.99 | 2.03 | 2.19 | 0.99 | 0.60 |
| 5                                   | 0.63 | 2.10 | 0.86 | 1.47 | 0.54 | 0.60 |
| 6                                   | 0.50 | 2.99 | 0.46 | 0.93 | 2.40 | 0.50 |
| 7                                   | 0.83 | 2.17 | 1.10 | 1.16 | 1.20 | -0.60 |
| 8                                   | 0.56 | 1.75 | 0.69 | 0.86 | 0.54 | 0.50 |
| 9                                   | 0.39 | 1.07 | 1.30 | 1.44 | 0.84 | -0.30 |
| 10                                  | 0.70 | 2.30 | 1.17 | 0.43 | 0.72 | -0.50 |
| 11                                  | 1.12 | 0.66 | 1.25 | 0.61 | 0.52 | 0.21 |
Negative values of the first car are due to the fact that, as a rule, drivers start to move a little before turning on the green signal of the traffic light, at the time when the red-yellow signal lights are on. Average values of the delay depending on the position of the cars in the queue before the traffic lights are shown at Figure 4. The average delay over the entire traffic flow is calculated without taking into account the delay of the first car, since this value is a single character and further along the flow there is no negative vehicle delay.

![Figure 4](image_url)

**Figure 4.** Average delay as on the car number in the queue to the traffic light post.

After measurements and subsequent calculations, it was found that the average speed of a car in the area under study with a length of 410 meters and an estimated density of flow of 207 cars per kilometre was 0.8 m/sec, or 2.88 km/hr. To obtain the value of the flow rate when using the vehicle assistance when driving in the blockway, the possible delay time is calculated, which is due to the peculiarities of the electrical devices and mechanisms of the brake system and the power supply system. Studies have shown that one calculation of the predicted motion path for 5 seconds ahead (i7 processor, Win7 environment, 16GB RAM) is approximately 0.05 s. [3] The relatively high dispersion value is explained by the delay in the process of data transmission from the standard rudder position sensor to the measuring complex, estimated at 0.05 s (sensor-ECU-CAN_car-CAN_IMC-record).

The total delay consists of several components:
1. The duration of the radar - sending and receiving a response signal - 0.05 sec;
2. Decision making by the central computer - 0.05 sec;
3. Computer signalling on mechanical drives - 0.05 sec; 4. The operation of mechanical systems, in particular brakes, is 0.1 sec (hydraulic drive is considered).

The travel time of the site is the sum of immediate movement and idle time. Idle time can be divided into a stop time for objective reasons (traffic light, obstacle) and a stop time for subjective reasons - attentiveness, reaction speed, decision making. Thus, the delay time t per hr is taken as idle time for subjective reasons and is replaced by the delay time of the electronics in the calculation process (total 0.25 sec). The exclusion of the human factor can increase the speed of movement. The same electronics independently adjusts the distance between vehicles.

The calculation of the time that will be spent on the passage of the study area, made by formula (1),

\[ t_{na} = t_n - t_{av} \cdot n + t_a \cdot n \]  

(1)

where
- \( t_{na} \) - full time of passing the part of the road, using automatic intellectual means, sec;
- \( t_n \) – full time of passing without assistant, sec;
- \( t_{av} \) – time of a human delay, sec;
- \( t_a \) – time of delay of automatic assistance devices;
- \( n \) – number of cars in the jam
Having received a new travel time for the site, a new average speed was determined for the surveyed site, which is 1 m/s, or 3.6 km/h. Based on the data obtained, it can be concluded that due to the introduction of an assistant in driving in a traffic jam at the site in question, it is possible to increase the speed by 0.72 km/h, decrease the travel time by 84 seconds, increase the throughput capacity by 148 vehicles per hour.

The study section of the road showed a low flow rate, heavy traffic and a large delay time of vehicles. Further, it was suggested that the possibility of reducing temporary losses and an increase in the flow rate due to the use of an assistant in driving in traffic jam was made. When using an intelligent driver assistance system, it is possible to reduce the vehicle's delay time when starting off by 5.44 times, thereby reducing the accumulated delay throughout the flow. This will increase the average flow rate, as well as the intensity of movement in this area.

References
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