A SYSTEM FOR SAFE OVERTAKING

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Abstract: A system for safe overtaking vehicles is based on the mutual exchange of important information, such as speed, mutual distance, GPS coordinates and vehicle dimensions (width and length). The system should indicate to the driver, using a traffic light symbol, whether he can or cannot overtake a vehicle. The article aims to analyze how the different parts of the system work and communicate with the Intelligent Transportation Systems. It further explores the format of the data frame communication.

Keywords: GPS, speed, distance, width, length

1. INTRODUCTION

Accidents on our roads have become everyday parts of our lives. Since 1982 has this number been continuously growing and achieved its maximum in 1999. Since then there have been intensive efforts to decrease the number of accidents and in comparison with 1999 there is currently only one third of them. However, this does not mean that we are satisfied with this number. Decreasing the number of car accidents is still being worked on. The system of safe overtaking described here could be an asset for that. Its purpose is to decrease the number of accidents on blind road corners and with help of mutual exchange of important information concerning speed, position and time. The system will set the particular distance and the meeting point and according to that it is able to find out what chance of success has the overtaking car. The system should be as simple as possible so as not to disturb driver´s attention and it will be possible to equip it with the system for safe overtaking, as well as with the voice signal [1, 2].

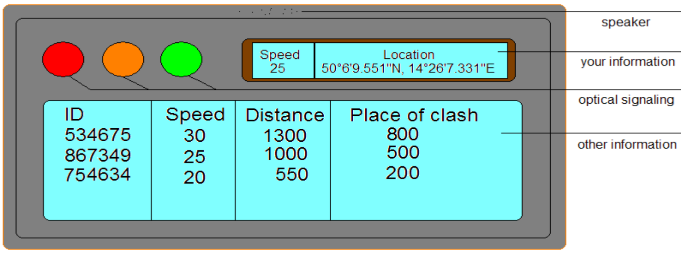
2. PARTS OF THE SYSTEM FOR SAFE OVERTAKING

The system for safe overtaking should comprise the parts like "on board unit", "secured data protocol", "road unit" and "information system centre". These parts are described herein.

2.1. ON BOARD UNIT

On board unit is user´s interface of the system for safe overtaking. It is vital that the system does not distract the driver while driving. It is easy to control and understand it according to visual and voice signals see picture 1. When the driver light signals the change of direction, e.g. when overtaking, a check of successful overtaking manoeuvre probability is carried out. Information based on communication with the car driving in opposite direction is processed and evaluated and it notifies the driver of the given situation. Green colour means that the car will safely overtake, red colour signals danger of crash. Orange colour will notify the driver that the car is in the overtaking space and upon attempt at overtaking; there is a risk of collision. At the same time it will signalize an early change to green colour; it means that it will be possible to overtake the given car. In picture 1 you can see two displays. One with information on speed and position GPS coordinates of the car. Below, there is the second display with "ID" of other drivers, with speeds, distances between the overtaking and opposite-direction driving car and the meeting point. The whole device is positioned in the visual angle so as the driver is not forced to monitor the situation while driving.

The device is relatively small and portable, and installation should be simplified to enable its usage also by a layman.



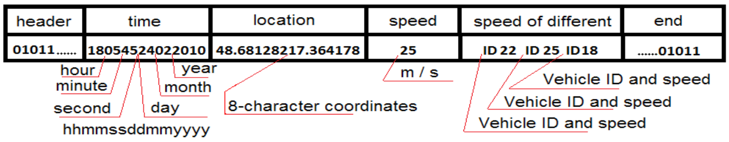
Picture 1: On board unit

2.2. DATA FRAMEWORK

Proposal and administration of the communication protocol by means of which the communication between the cars will be initiated. The whole communication process could be divided into three main parts. Initiating communication with authorization and authentication, own communication and termination of communication. Upon initiation of communication, there should be a follow-up process of authorization, after authorization there should be some communication at which the data whose structure is in picture 2 are send. The protocol structure comprises the following entries:

Heading - protocol data (packet identification, marking of packet commencement, etc.)
Time - the time stamp when the message was sent.
Position - GPS, record on position of the car.
Speed - actual speed of the car.
Speed of other cars in the given area.
Termination - finishing the packet framework.

According to the type of used method to set the distance of the cars, there will be a gradual or lump-sum exchange of information. Thanks to the system flexibility there is no problem to integrate this part of the protocol into the existing system as an additional application. It is the simplest protocol structure to secure the overtaking. Time transfer and speed of transfer is within 100ms and the condition for safe communication is complied with thereby.



Picture 2: Protocol structure to secure the safe overtaking

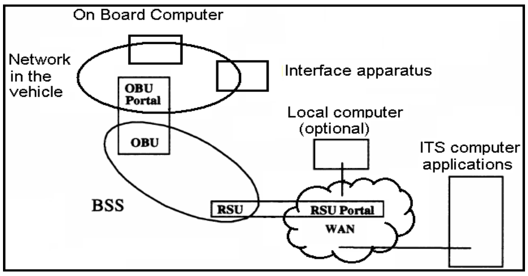
When proposing the protocol for transfer between the cars, emphasis was put mainly on reliability, safety and speed of protocol delivery. First and the main problem is the time between receipt and sending the message during which the car drives certain distance. During such interval there may be divergences of speed and distance. Upon receipt of the first series of data from the second car, the car could set the expected speed and distance which the car has driven in the meantime; compare it with the accepted information on actual distance and speed. The second serious problem is the possibility of delay up to 100ms at which the on board unit switches to the hearing mode, which could lead to continuous switching and might lead to the problem of loss.

2.3. ROAD UNIT

Road unit is a reserved transmitter with the short distance receiver, which is installed along the road or pavement. Road unit may be installed in the cars or hold in hands but it can operate also if the unit is stationary. Road unit is limited to the place where there is a licence permit for usage. It is permitted to use the portable or hand road unit on the control channel and service channels where they are not in defiance of the licence conditions of the frequency range. Road unit emits the data to on board units or it exchanges the data with on board units in its communication area. Road unit provides allocation of a channel whose task is to help the on board units in their communication areas in case of need [3].

2.4. INFORMATION SYSTEM CENTRE

The information system centre serves for connection between the on board units and road units. Concurrently it´s role is to store the data from the cars for possible confrontation with on board units. Using this system it is possible to send other useful information, for example road blocks, road fees and media purposes.



Picture 3: Block display of the system for overtaking

In Picture 3 you can see the system block scheme for safe overtaking. It is possible to see the motor vehicle with the onboard unit of data-free connection with the road unit and connection to the information system. [3].

3. IMPORTANT PARAMETERS OF THE SYSTEM

According to statistics the most frequent crashes are at the overtaking manoeuvres [2]. What is important for overtaking is to set the distance between vehicles. Moreover, it is speed and acceleration, setting the meeting point and calculation of safe overtaking.

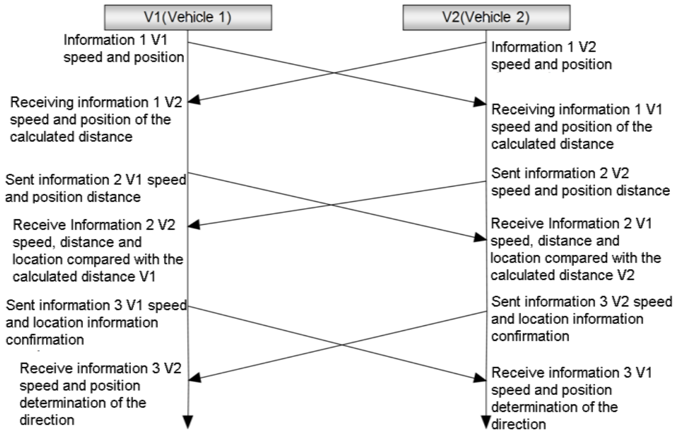
3.1. SETTING THE DISTANCE

To set the distance the following two methods can be used:

The first one is based on mutual exchange of three consecutive pieces of information and thereby it is able to set the mutual distance and also to determine direction of the car.

The other method is more applicable and expects some future communication between the cars. It is based on the principle when the car sends its speed, position and direction to its environment and expects an answer.

The method of Three Information is the first method, where the setting of distance is in question. In this method is vital to know your V1 parameter and parameter of the approaching V2 vehicle, which are sent at the same time. Verification process is set in three steps. V1 sends information on its speed coordinates with the position to V2 and waits for receipt of the same information from V2. Consequently after receipt and setting of position coordinates it will determine distance of the cars. At that moment it sends the other part of information, again about speed and position coordinates and it also adds information on V2 distance. V2 will carry out the same procedure with the received information and will send information on speed and position coordinates and will add its calculation of distance. Since both sides have sent their coordinates at the same time, their calculation is compared and their data should be equal. In the last step, the information on speed is sent, verification of position coordinates may be finishing and it is also able to set the direction with the help of three pieces of information on position. In case of non-compliance or if one of the verification signals is not delivered, new synchronization will be requested and thereby the whole process will be repeated from step one (sending information on position and speed). Communication is displayed on the following Picture 4.



Picture 4: Communication with V1 and V2

The second method of complete information is based on the principle of sending the messages with complete information in the course of one second. The message format reads: time, speed, position coordinates and destination where the vehicle is heading (with exact points which the vehicle is to cross). It is important that the time is synchronized since one second is a very long time interval during which the vehicle is able to drive several tens of metres. The method requires bigger memory on user is part that is sending the message. After having sent the message it expects the back communication from the other vehicle which enters the circuit of 1 km. At the moment of message receipt, it is compared with the time in the vehicle database, on the basis of which it will calculate distance and the meeting point. The cycle is repeated and the divergence which occurs between the time intervals and the calculations that set the distance between the vehicles is diminished.

3.2. SPEED

Speed *v* of an entity is the vector value, defined as change of entity position (thus the path segment, *ds*) divided by time during which the change occurred (*dt*). It defines the rate by which the position of the entity is changed in time. Speed unit in the SI system is meter per second [m/s]. Common unit is also kilometre per hour [km/h]. If the entity moves evenly and in the course of time *t* (*s*) it drives the path *s* (*m*), its speed is calculated using the formula (1).

$$v = \frac{s}{t} \qquad (1)$$

3.3. ACCELERATION

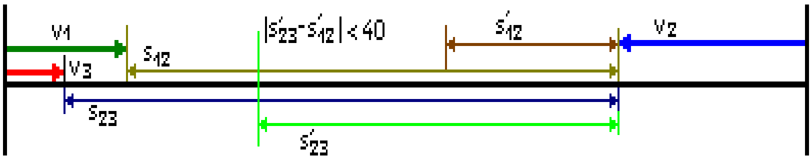
Acceleration is a physical quantity that shows change of speed per a unit of time. In the SI system, unit of acceleration is m/s^2 (meter per second2), marked as *a*. During calculation it is necessary to divide *v* by 3,6 to convert the speed from km/h to m/s.

$$a = \frac{\Delta v}{\Delta t} = \frac{\Delta v_2 - \Delta v_1}{\Delta t_2 - \Delta t_1} \qquad (2)$$

Task of the system is to notify the driver while overtaking to speed the vehicle up and thus prevent a crash. Concurrently it should warn the vehicle driving opposite that there is a car driving opposite which is trying to overtake and that it must slow down in case it wants to avoid collision, which could occur according to calculations. Based on the knowledge stated below it results that the system should serve as an aid and information.

3.4. Calculation of Safe Overtaking

Calculation of safe overtaking is necessary, although it has only informative character in the system. Since there is a known formula from Physics for speed and acceleration, which we mentioned earlier, we are able to determine, with the help of parameters acquired from GPS, if the vehicle is able to safely overtake the other vehicle (see formulas 3 and 4). Safe distance for overtaking is the distance of 40m and it is the minimum distance which must be kept between the overtaking and opposite driving vehicle. The law says that the oncoming vehicle should not be limited or threatened. To be limited or threatened is if the driver of the oncoming vehicle has the feeling of danger and must decelerate. Figure 5 shows the v_1 - speed of the overtaking vehicle, v_3 - speed of the leading vehicle v_2 - speed of the oncoming vehicle, s_{12} - distance between v1 and v_2, s_{23} - distance between v_2 and v_3, s'_{12} - point of passing of v_1 and v_2 from v_2, s'_{23} - point a passing of v_2 and v_3 from v_2, $|s'_{23}-s'_{12}|<40$ - the difference between the distances.



Picture 5: Illustration of safe overtaking verification

$$S'_{12} = \Delta v_2 . (s_{12} / (\Delta v_1 + \Delta v_2)) \qquad [m] \qquad (3)$$

$$S'_{23} = \Delta v_2 . (s_{23} / (\Delta v_2 + \Delta v_3)) \qquad [m] \qquad (4)$$

We consider overtaking as safe if the condition applies from the formula (5) if the track which is driven by the car in opposite direction while overtaking is bigger than the track which is driven by the opposite driving vehicle by the distance stated by us.

$$|S'_{23} - S'_{12}| < 40 \qquad [m] \qquad (5)$$

It is important to realize that we have moved on theoretical surface, we have counted only with evenly accelerated movement and constant speed. In the real world, the unevenly accelerated movement of vehicles and changeable speed is frequent. The system operates only on informative basis and depends on several parameters; resulting values might not be extremely precise; estimation is also important. It would be possible to simply implement the system so as not to distract the driver but clearly signalize (green light, orange light, red signalization) the option to overtake. He would not need to be interested in calculations.

4. CONCLUSION

The system is very interesting mostly because it is easily applied if an appropriate communication technology is selected. The system works with visual as well as voice signalization to signalize the car overtaking. There are formulas for setting the safe overtaking and data framework for communication between the cars.

ACKNOWLEDGEMENT

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