Research on Fatigue Driving Monitoring Method Based on Cooperative Vehicle Infrastructure System

Gao Jin
Research Institute of Highway Ministry of Transport.
Research Associate at Vehicle engineering.

Abstract

Aiming at the serious impact of fatigue driving and the imperfection of the existing monitoring methods, this paper proposes a fatigue driving monitoring method based on the characteristics that the driver makes the car sway in the lane when driving fatigue, combined with the cooperative vehicle infrastructure system technology. The method based on the most intuitive response to driver fatigue driving led to the vehicle in the driveway swing forward "standard deviation of relative lateral displacement between vehicle and lane", put forward the concept of fatigue index, according to the fatigue index to determine the fatigue level, with the advantages of high reliability, high measurement accuracy, It eliminates the influence of misjudgment or low accuracy caused by human factors on fatigue driving judgment, and solves the problem of frequent false positives.

Keywords: Fatigue Driving， Cooperative Vehicle Infrastructure System， Fatigue Index；

1. Background

Road traffic system is a complex system composed of people, vehicles and road environment. The instability or imbalance of any factor in the system may produce potential risks and lead to traffic accidents. Among the causes of various road traffic accidents, the factors related to people are the main factors that lead to traffic accidents, especially the fatigue driving problem. How to prevent and control traffic accidents from the driver's point of view has become a common concern of the government and the society. Aiming at the above problems, this paper proposes a driver fatigue driving monitoring method based on cooperative vehicle infrastructure system technology.

Fatigue refers to the phenomenon that the brain, muscles or other organs weaken their functional response due to excessive consumption. Driving a vehicle in a state of fatigue is called fatigue driving. After fatigue, the driver's physiology changes and affects driving behavior, which is manifested as weakened perception function, decreased attention, driving operation behavior disorder, prolonged reaction time, easy to cause errors in judgment and operation errors, easy to occur road traffic accidents.

At present, the mainstream technology for fatigue driving monitoring is the identification based on the physiological characteristics of the driver and the identification based on driving behavior, such as the blink of an eye, mouth opening degree, nod frequency, pulse and heart rate, or the identification based on the steering wheel Angle and braking behavior, etc. Monitoring tools are sensors, cameras, dashcam, worn pulse meter and so on. Infrared vision sensor can directly detect the driver's facial features, but individual differences in the face lead to a large problem of misjudgment of the technical route. Infrared supplemental light can also stimulate the driver's vision, which has a great impact on the driver's normal driving behavior. There are also visual problems with the camera head being placed directly in front of the driver. Tracking the driver's vehicle control state can detect whether the driver is in a state of fatigue driving, but the accuracy is not high because there is no reference to the road conditions.

2. Fatigue Driving Monitoring Method Based on Cooperative Vehicle Infrastructure System

In view of the inaccuracy of vehicle control caused by the driver's tired driving behavior disorder and prolonged reaction time, the vehicle trajectory cannot be corrected in time, resulting in the characteristics of vehicle rocking forward in the lane or even deviating from the lane. In this paper, a fatigue driving monitoring method based on cooperative vehicle infrastructure system is proposed to detect drivers' fatigue driving. The method does not depend on the physiological characteristics and driving behavior of the driver, and only needs to identify whether the driver is in a state of fatigue driving through the driving state of the vehicle.

2.1 Lateral Displacement of the Vehicle Relative to the Lane

When the driver is tired driving, the operation behavior is maladjusted and the reaction time is prolonged, which will lead to the inaccurate vehicle control, and the vehicle can not be corrected in time, which will cause the phenomenon of the vehicle rocking forward in the lane. In this paper, lateral displacement of the vehicle relative to the lane (L) is put forward, which is used to represent the relative lateral displacement between vehicle and lane within a certain time window, so as to intuitively and accurately reflect the phenomenon of vehicle rocking forward in the lane.

The “L” refers to the deviation of vehicle in the direction perpendicular to the lane driving base line. Generally, the center line of lane is selected as the measurement base line. Select the center line of the lane as the base line, and set the marking method of the relative lateral displacement L between the vehicle and the center line of the lane. For example, along the direction of the vehicle, if the center line of the vehicle coincides with the center line of the lane, it is marked as 0; if the center line of the vehicle shifts to the left, it is marked as positive; if the center line of the vehicle shifts to the right, it is marked as negative; It can also be: along the direction of the vehicle, if the center line of the vehicle coincides with the center line of the lane, it is marked as 0; if the center line of the vehicle shifts to the right, it is marked as positive; if the center line of the vehicle shifts to the left, it is marked as negative.

2.2 Standard Deviation of Relative Lateral Displacement Between Vehicle and Lane

In this paper, a statistical analysis method of standard deviation is used to extract features from a large number of the "L" sample data within the detection window. The standard deviation of relative lateral displacement between vehicles and lanes (L_{std}) is used to represent the key features of a large number of relative lateral displacement data of vehicles and lanes. In order to further intuitively and accurately reflect the phenomenon of vehicles rocking forward in the lane.

Firstly, the average lateral displacement of vehicles within a certain time window is calculated, which is the mean of the relative lateral displacement between vehicles and lanes (L_m). Similarly, the lane centerline is selected as the base line. When the sample data volume is N, the calculation method of the mean the “L_m” of the relative transverse displacement between the vehicle and the lane centerline is shown in Formula 1, where L_i is the relative transverse displacement between the vehicle and the lane centerline of sample i:

$$L_m = \frac{1}{N}\sum_{i=1}^{N} L_i \qquad (1)$$

The “L_{std}” was further calculated. The lane centerline was also selected as the reference line. When the sample data volume was N, the calculation of The “L_{std}” was shown in Formula 2:

$$L_{std} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(L_i - L_m)^2} \qquad (2)$$

2.3 Determine the Fatigue

According to the test and data statistics, due to the difference of vehicle size, drivers in the same fatigue state will produce different “L_{std}”, and the generated “L_{std}” is proportional to the width of the vehicle. Therefore, the fatigue index (the ratio of the L_{std} to vehicle width) was proposed to eliminate the influence of different vehicle widths on the standard deviation of vehicle and lane relative lateral displacement, and to unify the corresponding relationship between fatigue degree and detection index, so that the method could adapt to different vehicle types. The calculation method of fatigue index Fi is shown in Formula 3:

$$F_i = \frac{L_{std}}{\text{vehicle width}} \quad (3)$$

2.4 Specific implementation method

Figure 1 shows the layout of the RSU monitoring system for the implementation of this method. A number of the RSUs are arranged at intervals along the road side, and the OBU is installed on the vehicle. The RSUs communicate with the OBU to realize the identification of vehicle identity and position. The distance between two adjacent road side units shall be designed according to the full range of signal capture without loopholes. The RSU has a high-definition camera that can accurately capture the “L” centerline at a fixed frequency of 5Hz. the “L” can also be based on vehicle positioning, vehicle vision sensor acquisition.

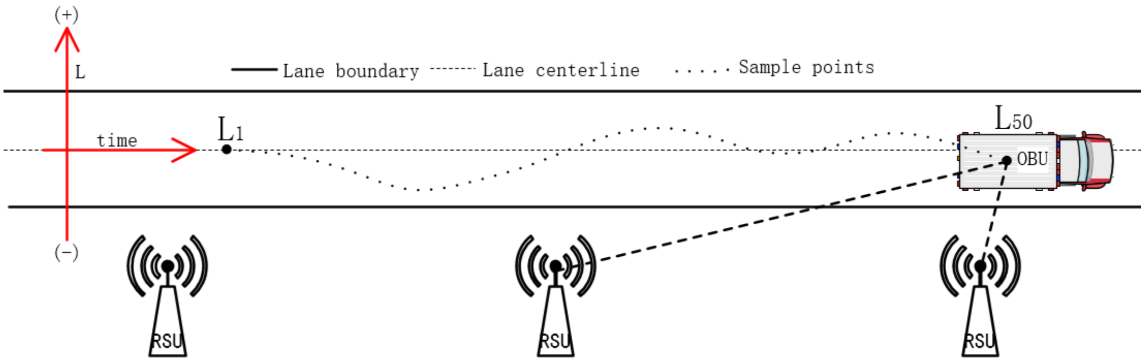

Figure 1 – Schematic diagram of monitoring system

Step1: Pre-set the marking method of the “L”, set the time window of a monitoring sampling, the sampling step, and the sample data volume N collected within the time window. Let the vehicle drive in the monitored section, turn on the RSUs, RSUs and OBU uninterrupted communication, RSUs respectively collect the relative lateral displacement of the vehicle and the lane center line at the time of Li, i =1,2... N, send to the OBU.

Step2: Calculate the “L_m” according to Li:

$$L_m = \frac{1}{N}\sum_{i=1}^{N} L_i \quad (1)$$

Step3: Calculate the “L_{std}” according to Li and the “L_m”:

$$L_{std} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(L_i - L_m)^2} \quad (2)$$

Step4: Calculate fatigue index Fi according to the “L_{std}”:

$$F_i = \frac{L_{std}}{\text{vehicle width}} \quad (3)$$

Step5: Grade the fatigue degree according to Fi:

The pre-established fatigue grade table is shown in Table 1, among them, S1 and S2 need to be determined statistically according to a large number of tests:

Table 1 - Fatigue grade

number	Fatigue index range	The degree of fatigue
1	$F_i \geqslant S1$	No obvious fatigue characteristics
2	$S1 < F_i < S2$	Slight fatigue
3	$F_i \geqslant S2$	Severe fatigue

Then, according to the measured Fi, the fatigue driving condition is monitored. During the monitoring process, if the turn signal is turned on, the monitoring will be stopped and the monitoring will be resumed after the turn signal is turned off. When fatigue driving is detected, the RSUs alerts the vehicle via cooperative vehicle infrastructure system.

3. Conclusion

The concept of fatigue index is proposed based on the " L_{std} " which can directly reflect the driver's fatigue driving leading to the vehicle rolling forward in the lane, according to the fatigue index to determine the fatigue level, with the advantages of high reliability, high measurement accuracy, It eliminates the influence of misjudgment or low accuracy caused by human factors on fatigue driving judgment, and solves the problem of frequent false positives. This method does not need to install sensors, cameras and other tools on the car, especially does not need to put the tools on the driver or front block the field of vision, does not affect the driver's operation, does not produce visual stimulation for the driver, solve the problem affecting the driver's normal driving. The detection index is simple to obtain, and can be obtained through a variety of ways, even without adding on-board parts, which solves the problem of the implementation of fatigue driving monitoring to modify the vehicle and increase the vehicle cost.

4. References

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