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Effectiveness Study of Ambulance Avoidance Reminder Function Combined with 45-Degree Oblique Stopping Method in Navigation Software

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Abstract: In recent years, the news of car owners avoiding emergency vehicles has been widely discussed by the society. With the introduction of related functions in domestic mainstream navigation software, how to give way to ambulances has become a major problem. Statistically, the 45° diagonal parking method, which is necessary to give way to ambulances, has yet to increase in popularity in China. 45° diagonal parking is a method of parking a vehicle in a specific traffic scenario. It is a method of parking a vehicle in a specific traffic scenario. It is defined as: when an emergency situation arises and it is necessary to give way to a special vehicle (e.g. an ambulance, a fire truck, etc.), the driver parks the vehicle diagonally at an angle of approximately 45 degrees, thus quickly opening up a lane for the special vehicle to pass through without disturbing the order of the traffic as much as possible. This method aims to improve the efficiency of special vehicles in emergency situations and minimize delays caused by traffic congestion. Therefore, the author will mainly focus on the 45° diagonal stop method, which is the mainstream give way method, and verify the effectiveness of the function of the navigation software reminding to give way by means of mathematical modelling, and provide improvement methods for the results.

Keywords: Ambulance, 45° Oblique Stop Method, Navigation Software, Mathematical Modelling

1. Introduction

Ambulance, as a special medical transport tool, is a special vehicle equipped with professional medical equipment and first-aid personnel for emergency medical rescue and transfer of the sick and injured. Its role is mainly reflected in its rapid response in emergency situations, providing on-site first aid and safe transfer services for the injured and sick, ensuring that the injured and sick can receive professional medical treatment in a timely manner, and playing a key role in saving lives and promoting recovery. According to news reports, during the Chinese New Year period from 10th to 17th February 2024 alone, the number of pre-hospital emergency services in Shanghai reached 17,409 vehicle trips, reflecting the importance of ambulances.

It is common for ambulances to be blocked by traffic congestion, which can cause patients to miss critical treatment opportunities and ultimately lead to death or poor treatment results. According to surveys, the probability of ambulance traffic jams is quite high, exceeding 30%. The prevalence of this situation is partly due to traffic congestion in the city itself, and partly due to the fact that many drivers lack the awareness of giving way, or do not understand how to do so correctly and efficiently.

Despite the introduction of navigation software that reminds drivers to give way, in traffic jams, especially those caused by car accidents, the lack of awareness of drivers to give way and their lack of understanding of how to do so properly and efficiently often leads to delays in treating patients, resulting in serious consequences. At the same time, even if the ambulance deployment and route planning have been continuously optimized, it is still difficult to avoid being blocked during morning and evening rush hours.

2. Research Background

2.1. Research on ambulance give way methods

According to the survey, among all the existing give way methods, the most effective and universal is the 45-degree diagonal stop give way method. This is a method that can be applied to ordinary roads, tunnels, elevated and other congested road sections to make room for rescue vehicles to pass. The advantage of this method is that it is quick and highly feasible. Drivers of other vehicles in front of the ambulance only need to stop their vehicles at 45° to the front in order to make enough space for the ambulance at the rear. In order to prove the feasibility of the 45° stopping method, Table 1 compares the three most well-known methods of giving way, and Figures 1 to 3 show the diagrams of the three methods.

Table 1. Analysis and Comparison of the Advantages and Disadvantages of Existing Give Way Methods

Giving Way Methods	Advantage	Disadvantage
Normal pulling over and waiting	Relatively simple manoeuvre, clear to give way.	Relatively slow and may cause some delay.
Parallel Give Way	A wider lane can be opened up quickly for the ambulance.	It requires high road width and may affect other lanes of normal traffic.
45°Slant Stop	Giving way is fast and can open up a wide lane for the ambulance in a short time.	Requires certain driving skills and spatial judgement, unskilled drivers may not operate properly.

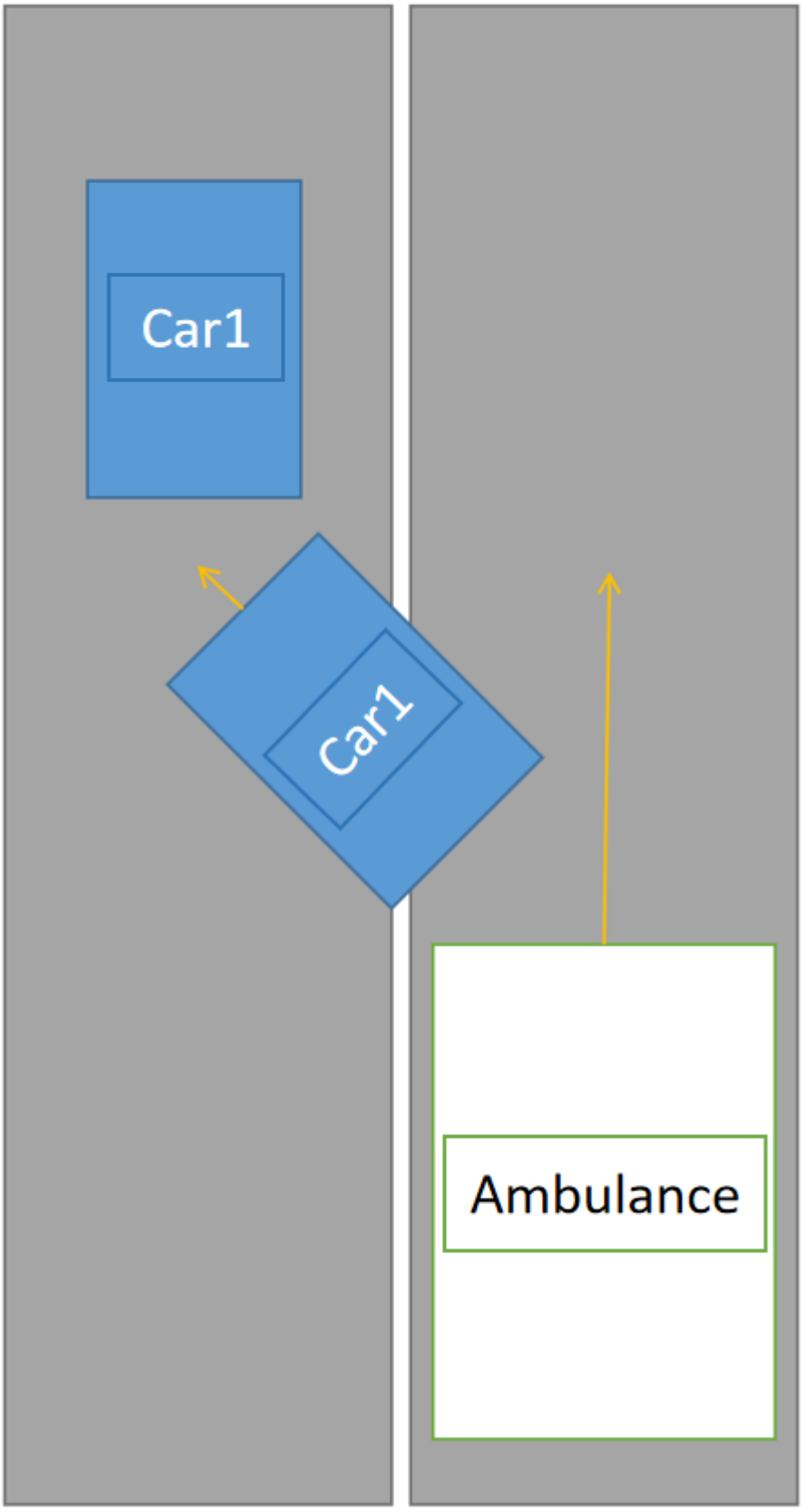

Figure 1. Normal Pull Over Waiting Schematic

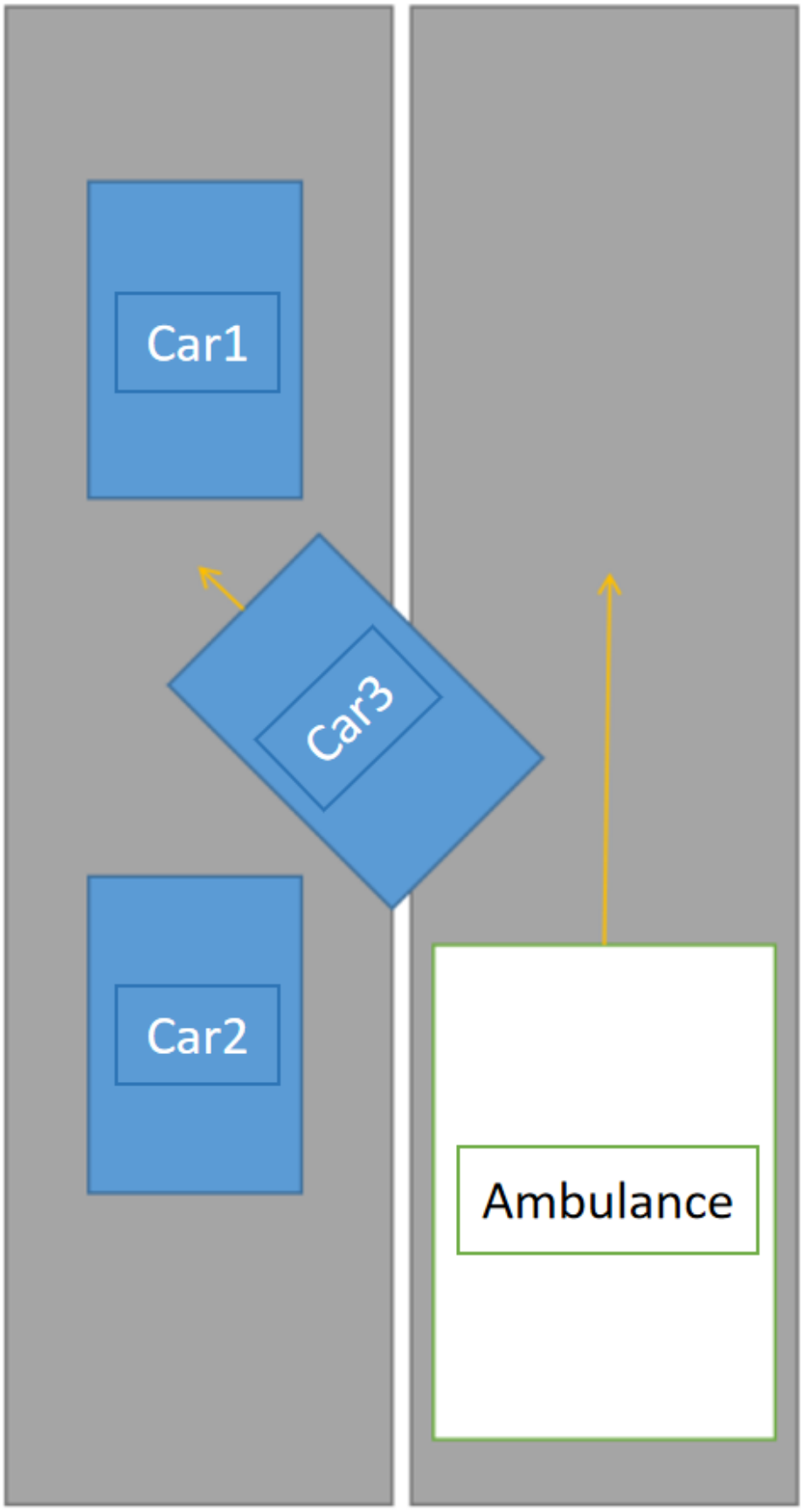

Figure 2. Parallel yielding schematic

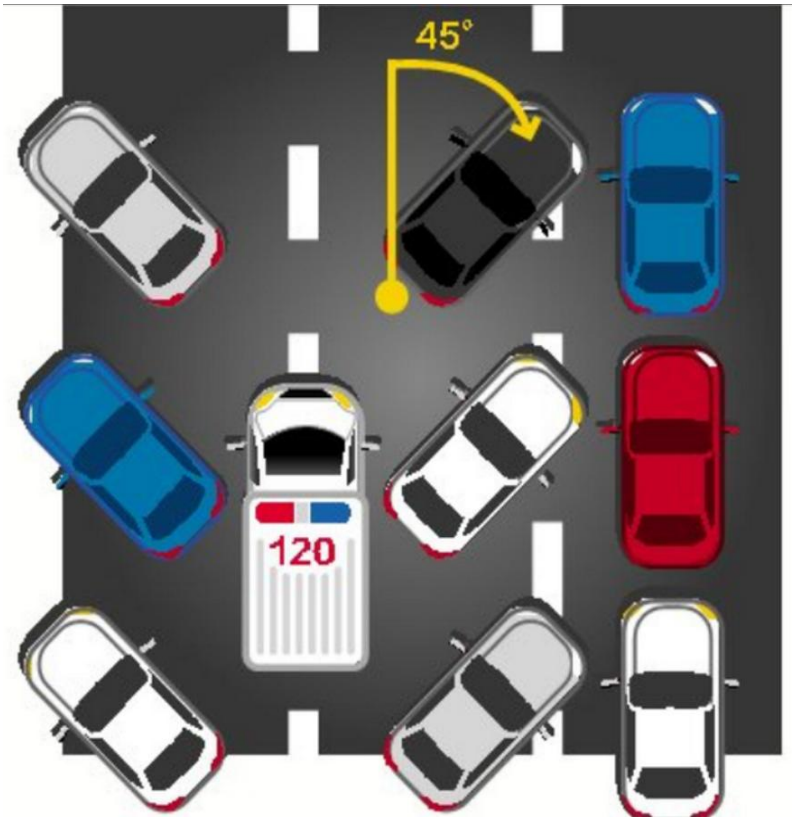

Figure 3. Schematic diagram of the 45-degree slant stop method

From the above figure, it can be seen that the 45° diagonal stop method is the most efficient and at the same time less demanding on the road width, which is suitable for giving way in traffic jams. Therefore, this paper takes the 45° diagonal stop method as a reference, compares the time consumed in giving way with the time originally consumed in traffic jams, analyses whether the reminder avoidance function of the navigation software is effective in reminding drivers to give way, and decides whether it is necessary to add a link to teach drivers how to give way with the 45° diagonal stop method.

2.2. Survey on the popularity of the 45° diagonal stop method

According to the data in the paper, only half of the drivers in China know about the 45° stopping method, of which 21.66% have never heard of it, and 27.65% have heard of it but don't know it in detail. This will also be analyzed as a reference data in the validity test to be conducted later in this paper.

Table 2. 45° stopping method

4. 请问您了解45°斜停法嘛? [单选题]

选项	小计	比例
了解	110	50.69%
没听说过	47	21.66%
听说过但是不详细知晓	60	27.65%
本题有效填写人次	217	

表格 饼状 圆环 柱状 条形 折线

3. Mathematical model for validity testing of the 45° inclined stop method

3.1. Table of symbols

Table 3: symbols

d	Length of journey in traffic jam	Metre(m)
V_a	Average speed of ambulance traffic	Metre per second(m/s)
V_s	Vehicle travelling speed on the blocked section	metre per second (m/s)
t_1	Time required for an ambulance to pass through a traffic jam when it is being avoided	Seconds (s)
t_2	Time required for an ambulance to pass through a traffic jam when it is blocked	Seconds (s)
t_b	Time required for the driver to avoid the traffic jam	Seconds (s)

3.2. Raw data

Table 4: Raw data

Category	Minimum data	Maximum data	Final value	Unit
Width of SUV	2	2.2	2.1	Metre(m)
Length of SUV	4.2	5	4.6	Metre(m)
Length of Normal cars	/	/	3	Metre(m)
Width of normal area	/	/	1.5	Metre(m)
Width of road	3	3.5	3	Metre(m)
	0.1	5	1.5	Metre(m)
Reaction time for human	/	/	0.3	Seconds (s)
Angular velocity(ω)	20	30	25	Degree per second(°/s)

3.3. Modelling

Assuming that the length of the lane is set to be d (m) and the average moving speed of the ambulance when it is blocked is (m/s), the time required for the ambulance to pass through the blocked section is:

$$t_2 = d/V_s.$$

When considering t1, which is the time required for the ambulance to pass when it gets the give way, then a variety of factors need to be taken into account, including variables such as the time difference between the different vehicles on the congested road that receive the give way message, the driver's reaction time, and the time of the give way.

Firstly, after receiving the yield avoidance reminder from the navigation software, the driver needs at least about 0.3 seconds of reaction time before making the yield avoidance behaviour. Starting from the first vehicle in the traffic jam section and followed by the rest of the vehicles, a reaction time of 0.3 seconds needs to be added to the final total time.

Secondly, when the driver makes an avoidance behaviour, the driver needs time to avoid the ambulance, and the demonstration results are shown below:

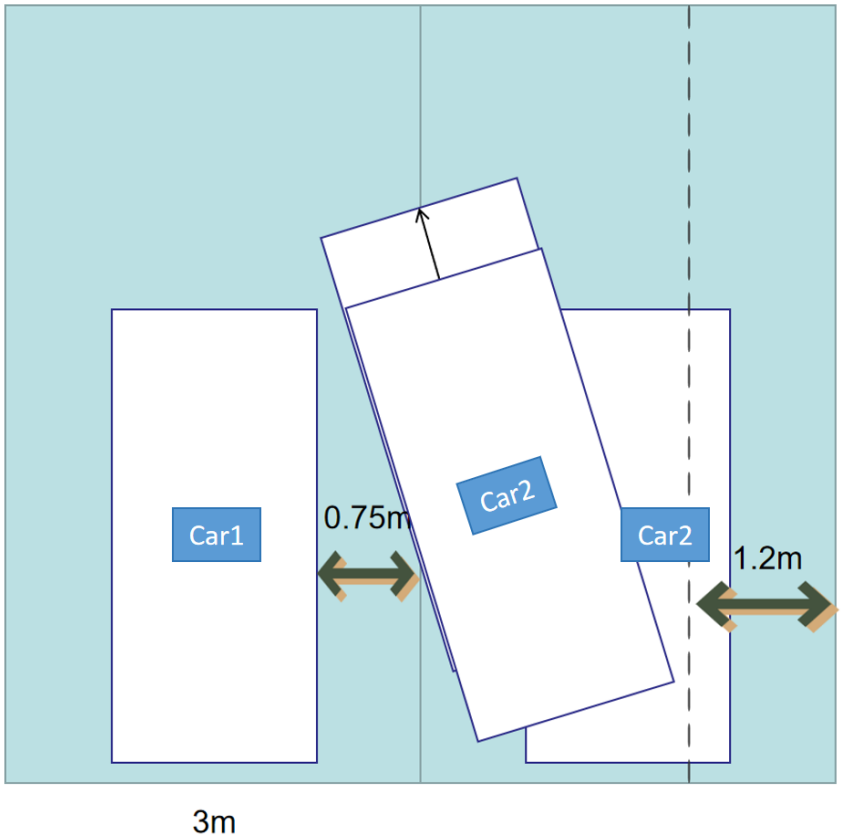

Figure 4. The driver needs time to avoid the ambulance

This indicates the need to find the avoidance time required by the first vehicle through the vehicle's avoidance speed.

In exploring the relationship between the time required for a vehicle to make a 45-degree angled stop and its angular velocity, we define the following variables: θ denotes the steering angle of the vehicle in degrees, ω denotes the angular velocity of the vehicle in radians per second, and tb denotes the time required for the vehicle to complete the steering in seconds. Based on these variables, we develop the following mathematical model:

$$\theta = \omega \times t_2.$$

By converting the 45-degree steering angle to the radian system (rad) and substituting it into the above equation, an expression for the time required for the vehicle to complete a 45-degree angled stop can be obtained:

$$t_2 = 4\pi/\theta.$$

After that, the total time taken by the ambulance to pass through the blockage after it has been avoided is obtained:

$$t_1 = 0.3 + 4\omega\pi + d/Va.$$

3.4. Comparison of the time required for an ambulance to pass through a congested road section

After obtaining the time required for the ambulance to pass through the congested road in two different situations, we will compare the size of t1 and t2 by substituting the existing data into the obtained formula and obtain the range of the value of d, which will be used as a basis for judging whether the function of reminding the avoidance by the navigation software is effective. If t1 is smaller than t2, it means that the reminder of navigation software is effective in most cases; while when t1 is greater than or equal to t2, it means that the programme still needs to be improved.

We need to make t1, i.e., the passage time of the ambulance after being alerted, less than t2, i.e., the passage time when it is blocked, which is obtained from the formula in Section 3.3:

$$t_1 = 0.3 + 4\pi\omega + d/V_a,$$

$$t_2 = d/V_s.$$

Substituting the relevant data gives:

$$t_1 = 0.3 + 0.16\pi + d/V_a,$$

$$t_2 = d/V_s.$$

The ambulance travelling speed Va is about 40km/h when it is on a normal call, while on a high speed it can reach 110km/h, so 60km/h is taken here, i.e. Va=16.7m/s. When it is blocked, the ambulance's travelling speed Vs decreases dramatically to about 10km/h, i.e. it is Vs=2.78m/s. The final substitution of the data can be obtained:

$$t_1 = 0.3 + 0.16\pi + d/16.7 = 0.803 + d/16.7,$$

$$t_2 = d/2.78.$$

When $t_1 < t_2$, it is necessary to satisfy:

$$0.803 + d/16.7 < d/2.78,$$

It is concluded that the navigation's give way reminder function is effective when d > 2.68m.

4. Assessment of model results

4.1. Analysis of model results

The result of d > 2.68m in Section 3 shows that the reminder function of navigation combined with the 45-degree diagonal stopping method is effective in most of the traffic jam situations. Of course, the model proposed in this paper is not yet very detailed, and there are certain conditions that have not yet been taken into account or added into the calculation, such as the effect of lane width on stopping speed, or whether the safety and efficiency of ambulance yielding will be affected under the premise that some drivers do not understand the 45° diagonal stopping method, etc. However, the results of the related news report show that the navigation alert function combined with the 45° diagonal stopping method is effective in most traffic jams. However, as reported in the news, the navigation alerts were still effective and reduced the number of ambulances blocked by nearly 50%. In the subsequent research work, we will further improve the model in this paper to give a more accurate assessment of the effectiveness of the 45° diagonal stop method.

4.2. Recommendations

Combined with the findings of this paper, we also put forward a little suggestion for further improvement of the navigation software: in order to avoid the driver not understanding the situation of different stopping methods, the navigation can be added to the software or the vehicle's in-vehicle software with an animation demonstration function, instructing the driver how to give way to enhance the efficiency of the give way, which helps to shorten the ambulance's time to drive through the blocked section in the blocking situation, and provide a greater guarantee for the patient's rescue and treatment. greater protection for patient treatment.

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