DESIGN OF TRAFFIC MONITORING AND SAFETY SYSTEM

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ABSTRACT

Road accidents have become more often nowadays. They lead to loss of property and most important lives of people. In most of the cases accidents occur when vehicles are fast and also there is least visibility of upcoming obstacles in path. This less visibility or no visibility of obstacle is dangerous because driver anticipating the obstacle and the sudden appearance of obstacle can lead to loss of control on vehicles and cause a road accident. Problems here are that vehicles aren't visible in path when there is a curve bends, U turns or underground corners. These situations get more worse when conditions are foggy or rainy. If the driver is aware of these obstacles in path well before, they can get more time to react and less chances of getting frightened and lose control on wheels. Hence, we have designed a traffic safety system which can help driver to be alert if there is an obstacle on upcoming path which is not visible by use of electronic devices. Sensors are placed on different spots of roads like U-turns, Sharp bends or curve and underground parking lots. These sensors are connected to the LEDs via transmission cables. These LEDs will flash when any obstacle or vehicle comes in sensor rays. This flashing light will alert driver of some obstacle in path so they can slow down and align their cars accordingly to avoid collision. This proposed solution can be very useful than the other methods because it is simple that is less complex and easy to setup. Other methods or solution proposed are ineffective at very long ranges. They take up some space and power from vehicles whereas proposed solution by us needs no power or space in vehicle since, complete setup is outside the vehicle. Also, other systems are based on wireless systems which can get some delays in transfer of feedback which can be devastating whereas, proposed system by us is completely stationery setup with transmission cables. So least transfer issues and almost no connectivity issues.

Keywords: *Traffic safety, sensors, Electronic devices.*

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1. INTRODUCTION

1.1 The Problem summary

All around the world it is very common or frequent that you have heard of a road accident.
Reason stated are quite obvious that vehicles were too fast.
But the main reason comes behind is driver getting frightened due to anticipation of upcoming obstacles or

sudden realization of the obstacle.
Mostly it occurs where there is less or no visibility of path ahead specially at sharp curves, Hilly roads, canyons, U-turns and underground turns.
Hence, a proper solution to this is required to ensure safety of people while travelling.

1.2 Problem specification
Drivers are unable to see upcoming obstacles on path in various situations:
Hilly roads or unpleasant weather conditions make visibility very less of upcoming vehicles in path, so a system is required to be developed so that drivers are alert of any such obstacles on roads.
Confusion among drivers:
In various conditions or situation drivers anticipate the movement of upcoming vehicle and might judge wrong which creates confusion among drivers and can lead to accidents.
Un-necessary braking and time consumption:
While judging or anticipating the obstacles drivers slow down at every curve or bend for no reason which takes up more time and energy produced by engine gets wasted as heat energy in brake drum or discs.
Stress and anxiety in drivers:
After sudden realization of obstacles driver may get frightened and lose control on vehicle and lead to an accident. This is more common among new drivers or learners.

2. LITERATURE REVIEW
There are already many solutions provided to this problem. We referred to various patents to extract some information to proposed solutions and find some limitations to them and overcome it.
2.1 SENSOR AND A SENSOR SYSTEM:
This solution had sensors fitted in vehicle which transmit rays to upcoming obstacle and receive them back as a feedback then alert driver with different sound effects or lights. The limitation we found here is the range is quite small and is more effective while reverse parking or detecting smaller obstacles near bumpers of the car.
2.2 SYSTEM AND METHOD FOR PREVENTING A COLLISION:
This system had a receiver fitted in car which receives feedback from already fitted sensing devices on road which provides information to user about upcoming path and obstacles on it. The limitation we found here is that it requires a power input system in vehicles which takes up some space and weight in vehicle also the transmission is wireless which can be delayed or in effective at times.
2.3 ROAD CONDITION DETECTING SYSTEM:
This system had infrared sensors to obtain details of not visible obstacles of upcoming path ahead and alert driver of it.
The limitation we saw here is it takes up some space and power input in vehicle which increase load on vehicle battery and also takes up useful space in cars.
2.4 SENSOR AND SENSOR SYSTEM: We referred to one of the sensor systems, its working, design layout and its applications of it in various fields and conditions.
2.5 Conventional method of putting concave mirror at the sharp bends are quite useful to some extent but it gets at time useless when the weather is foggy and rainy.
Hence a solution with good visibility and with high accuracy is needed to ensure safety.

3. DESIGN REQUISITE
Layout of sensing device and LEDs is available but the placing of those at accurate position needs to be done. This positioning will take into consideration many factors like braking distance, reaction time of driver and many more stated later.
So that there can be enough time to react and avoid mistakes by drivers being frightened of sudden obstacles.
The estimation of placement of sensors and LEDs based on theoretical and experimental results obtained from research papers as mentioned in references.
Alignment of sensors in the path: Sensors will be placed as shown in figure 1 below –

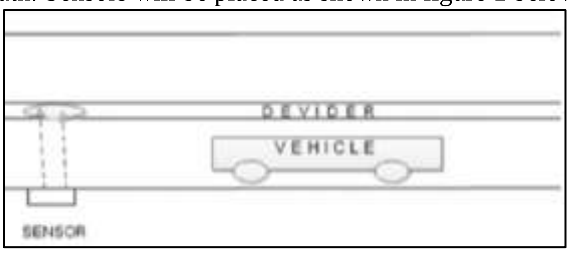


FIGURE 1- Sensor position

This type of alignment is better since it can sense almost all the vehicles passing through this particular region. This layout is beneficial as it will be easy to setup and less costly. Maintenance and other minor work will be easier. There is enough flexibility for change in position of sensor if required. Proper power facility can also be provided to the circuit and in no power conditions solar panels can be equipped easily by providing a column like structure like street lights to generate power to run equipment.

3.1Position of sensor:

This will play an important role as the placing of sensors will be done based on enough braking distance available before the collision.

3.1.1Braking distance based on Speed and coefficient of friction of road: As described in the Danish Road Standards and Guidelines, based on measurements of friction values for tire /roadway and the physical laws of deceleration. Here the braking distance is obtained from the speed, coefficient of friction and the roadway grade by applying the following formula:

$$l_{brake} = \frac{V^2}{2 \cdot g \cdot (\mu_{brake} + s) \cdot 3.6^2}$$

L brake = braking distance (m), V = speed (km/h), g = acceleration due to gravity (9.81 m/s^2), μ brake = mean coefficient of friction, s = roadway grade. The recommended friction values and the calculated braking distance (on level road) from the current Danish Road Standards and Guidelines are shown in Table 1. It should be noted that the Danish Road Standards and Guidelines often operate with an extra safety margin of +20 km/h when determining the braking distance. In the AASHTO Green Book, determination of the braking distance for use in calculating stopping sight distances has been altered from the more traditional calculation method using coefficients of friction (like the Danish) to a calculation method based on behavioral recordings and measurements from braking trials. Based on the findings of a large-scale measurement program indicate that by far the majority of all vehicles brake with a deceleration of more than 3.4 m/s^2. By applying 3.4 m/s^2, we obtain braking distances as shown in Table1. These values are the average values of several tests performed for various vehicles of different class and standards.

Speed (Km/h)	**Danish road Standards and Guidelines**		**AASTHO GREEN BOOK**
	Coefficient of friction	Braking distance (m)	Braking distance (m)
50	0.38	26	29
60	0.36	39	41
70	0.35	55	56
80	0.34	74	73
90	0.33	97	93
100	0.31	127	115
110	0.30	157	139
120	0.29	195	165

TABLE 1- showing Coefficients of friction and braking distance from the Danish Road Standards and Guidelines and braking distances from AASHTO Green Book

3.1.2 Braking distance based on Weather conditions:

Studies run on friction which are divided into three different categories:

1. The changes of surface texture and pavement materials, Geometric features and the fabric of tire on the friction coefficient.

2. Relation between Geometric Design parameters (such as radius of horizontal curves and vertical alignments, stopping sight distances the speed of vehicle, slope and Super elevation).

3. The effect of weather conditions on road surface and on friction coefficient.

In studies that are divided into category 1, the values of friction are acceptable unless the road surface loses its primary state, as an example, in case of snow drop and compacted snow or ice which causes the road surface to become unusual, the same friction coefficient cannot be used. This is because porous surface is covered with compacted snow and ice and low surface roughness has low impact on the friction coefficient studies in category 2, usually the friction coefficient is obtained by harvesting field of acceleration, speed and stopping distance of vehicles and also slope and geometric features Studies of category 3, the effect of weather conditions directly on road conditions and the value of friction coefficient is measured. In AASHTO Green Book 2011(3), the effect of weather conditions derived from designing parameters such as weight, size, the effect of center of mass and so are not considered numerically and precisely in sudden stops. The studies show that most drivers to stop suddenly while facing an unexpected object brake with the rate of deceleration greater than 4.5 meter per square seconds, and also about 90% of drivers under normal conditions brake with the deceleration rate of 3.4 meter per square seconds. In order to compare and include the value of friction coefficient in different weather conditions and relate its effect on Road friction coefficient while braking, it is necessary to use a relationship for manual calculations that the value of friction coefficient is applicable. Therefore, because current AASHTO (2011) is according to the changes of suggested values of speed and acceleration, instead of using current AASHTO (2001, 2004, 2011), AASHTO (1990 and before) is used in which friction coefficient is directly based on vehicle type and physical relationships. As it is shown in figure 2, there is no force toward forward and vehicle movement is gained through force interaction between friction and engine:

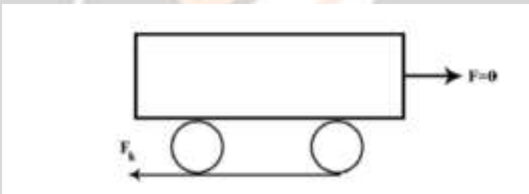


Figure 2. Forces

TABLE 2, shows the table of research that directly gives friction coefficient based on road surface conditions. (source mentioned in references)

DESCRIPTION	ICY	SNOWY	RAINY	WET	DRY
THE STUDY PRESENTS MAXIMUM AND MINIMUM VALUES	1.2326 0.049991	1.224 0.18735	1.093 0.82985	1.093 0.8645	1.0799 0.96122
JONES AND CHILDERS REPORTED	-	-	-	0.4	0.7
ICY TO DRY CONDITION STUDY	0.2	-	-	-	0.8
SPEED OF 93 to 97 Km/h	0.16	0.27	-	0.8	0.93
ON SIMULATION SOFTWARES	0.15 0.05	0.1943	-	0.5	1.2801 0.7

TABLE 2- Studies on coefficient of friction based on weather conditions.

3.1.3 Braking distance based on type/ class of vehicle:

Vehicles are available in different class and they have different built, performance and braking too. Hence, study on different class of vehicles is required to have better view of placing of sensors. So, a study of braking distance of different types of vehicles and their braking distance with coefficient of friction is shown below. (Source mentioned in references)

Road Surface Conditions	Icy	Snowy	Rainy	Wet	Dry	Dry1
μ (Coefficient Friction)	0.18	0.28	0.4	0.5	0.6	0.7
Braking Distance (Truck-Free) (m)	307.6144	187.9897	85.6759	85.6064	85.6039	85.6025
Braking Distance (Truck-Locked) (m)	307.5074	188.081	85.5267	85.485	85.4822	85.4806
Braking Distance (Bus-Free) (m)	311.4074	169.5349	116.537	115.6078	115.4796	115.3656
Braking Distance (Bus-Locked) (m)	311.5601	162.1888	113.516	113.05	113.0428	113.0279
Braking Distance (Sedan-Free) (m)	178.424	132.886	112.902	107.02	104.591	104.319
Braking Distance (Sedan-Locked) (m)	176.886	133.017	114.184	108.328	105.907	105.619
Current AASHTO (2001,2004,2011) (m)	-	-	-	-	-	-
Previous AASHTO (1940-1990) (m)(Sedan)	138.666	89.1428	62.4	49.92	41.6	35.6571
Jones & Childers (2001) (m) (Sedan)	166.4	124.8	83.2	70.72	41.6	-

TABLE 3- shows Braking Distance Based on Road Conditions for types of Vehicle (Speed = 80

3.1.4 Braking distance based on Driver's response time:

The driver's response time is critical to the braking process of the vehicle and therefore also has a significant impact on safety in critical situations. It can be defined as the time passing from the moment when a hazard occurs to the moment when the driver takes action to avoid it, by braking and/or turning the steering wheel. While, analyzing the driver's response time, when the hazard occurs, one should distinguish:

Perception time tr1- the period between the moment the hazard appears in the driver's field of vision and the moment the driver focuses his attention on it and recognizes it.

Basic psychological reaction time - includes the time of analyzing the situation by the brain and making a decision about the type of reaction (braking, bypassing an obstacle) and sending a signal by the nervous system about the start of the action to perform the manoeuvre (the beginning of foot movement in order to apply the brake pedal).

Foot transfer time - the time of the motor reaction consisting in transferring the foot from the accelerator pedal to the brake pedal.
The sum of the perception times (tr1) and the fundamental psychological reaction times (tr2) shows the mental reaction time.

Type of stimulus	Response time interval [s]
Simple	0,7 – 0,85
Complex, expected	1 – 1,15
Complex, unexpected.	1,3 – 1,5

Table 4. Average response times to different types of stimuli

3.1.5 Braking distance or stopping distance depends on many conditions like: -
Driver's ability/ reaction time (professional/ casual), brake pedal lever pressure, Tire pressure and friction, road condition, weather condition, mechanical accuracy of automobile build (brakes), type of brake (including type of liner and condition of liner), speed of vehicle, Vehicle condition (maintenance and years after built), total weight of the vehicle and many more. Hence, considering all of the factors is a quite cumbersome task. So, instead we searched for the average braking distance obtained by various theoretical and experimental values from the mentioned references and simplified the work by including a few studies. So, the position of sensor can be estimated by the average of speed of vehicles, road conditions and studies mentioned above for a particular route and hence, this sensor can be placed at effective distance to avoid collisions by providing enough braking distance for the vehicle.

4. IMPLEMENTATION

Implementation of proposed solution is explained below under different situations or circumstances.
Taking up a few cases like:

4.1 CASE 1. U-turns at highways or streets:
U-turns at highways are quite responsible and requires more attention towards coming vehicles in the lanes. Also, driver has to guess the upcoming vehicle's speed and this can make it more difficult as this requires proper judgement of coming vehicles. At times or some situation there is lack of view of upcoming vehicle which can be troublesome and lead to accidents since both of minimal field of vision or view for each other. Hence, we have drafted a layout of sensing device and its components to alert drivers of upcoming vehicles or obstacle.
In this case for example figure 3 and 4, car A wants to U-turn and hence it will slow down and move towards the righthand direction for U-turn. But the Car B coming from opposite lane has no idea of Car A taking U-turn and also car A doesn't have proper view of Car B coming towards it. This can get more worse when its night time, foggy or raining which makes visibility least. Hence, a proper safety system to alert drivers of upcoming obstacles is needed. So here 2 sets of sensing devices are provided which will sense coming vehicles and alert drivers by a flashing light placed at a good visual site. Sensor 1 will sense car A while making a U turn which will sense the car and generate feedback current, which will pass through LEDs which will flash and indicate Car B of Car A taking a U turn. Hence, Car B will be known to the car taking U-turn and respond more easily and quickly by changing lanes or slowing down. Similarly,

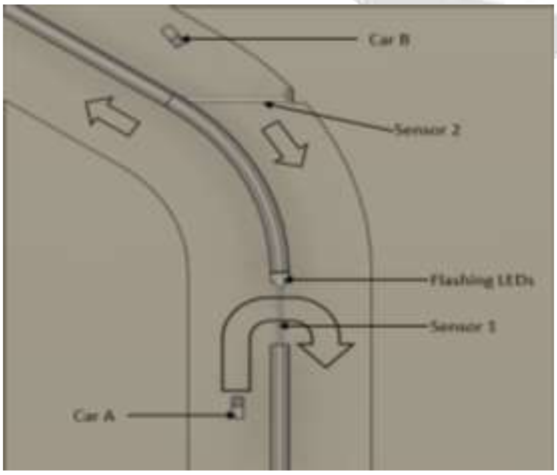


Figure 3- Top view of U-turn on highways

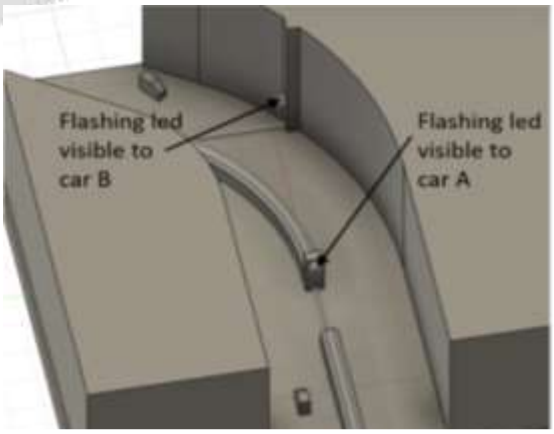


Figure 4- Other view of prepared model

sensor 2 will sense Car B and flash light for Car A which is taking U-turn. Hence, Car A will be also alert of Car B coming from opposite lane and wait for the vehicle to move away then safely take a U-turn.

4.2 CASE 2. sharp curves or canyon

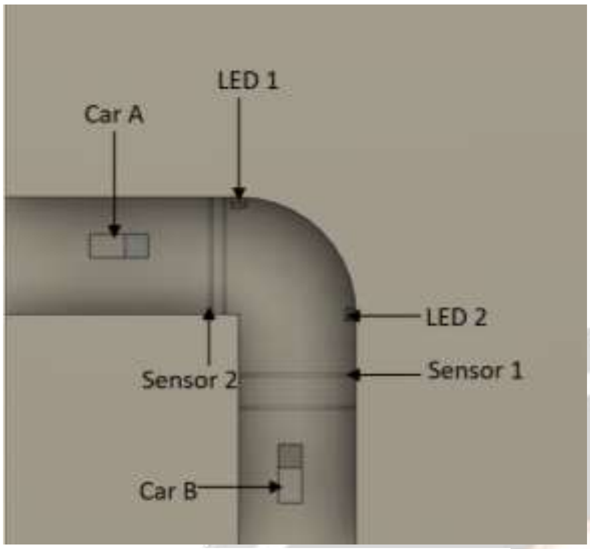


Figure 5- Top View at sharp bend

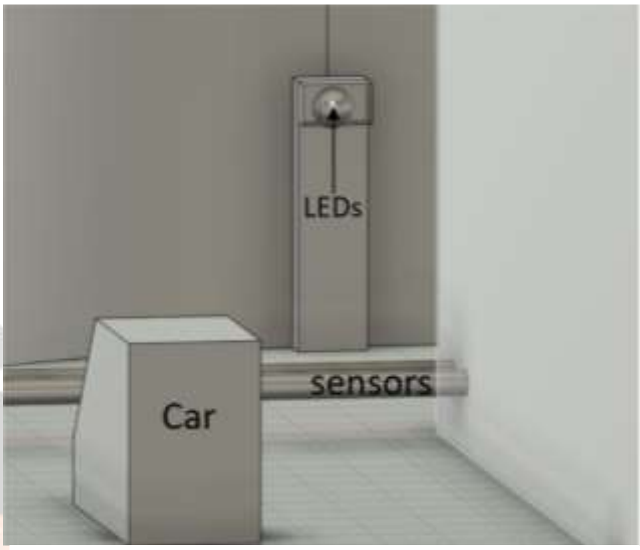


Figure 6- Other view of arrangement

Driving through curves /bends is always a difficult task. Since, drivers are unaware of coming obstacles. Most of the times they lose control just by getting frightened of sudden appearance of a vehicle. This can get risky and may lead to loss of property and precious life.

In this case we take for example refer figure 5 and 6 where Car A and Car B have almost no view of each other.

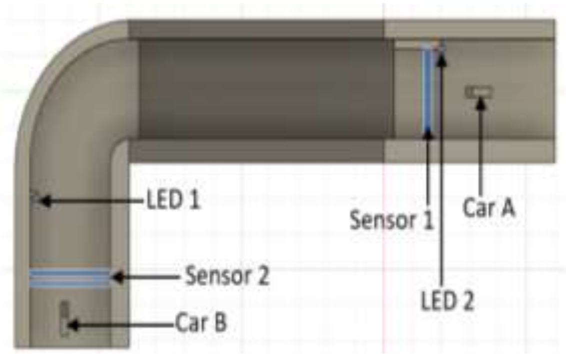
Blowing horns and flashing dippers can alert each other but by human errors or any other problems of vehicle like horns aren't working and headlamps are broken then it gets difficult to judge coming vehicles. Also, people anticipating the vehicle coming make them brake at un-necessary points which wastes the energy developed by engine as heat energy in brake drums or discs and friction. This can also lead to loss of control on wheels being frightened of the situation. Hence a proper system is required to be given at such places so that drivers are aware of each obstacle and driver feels relaxed while driving and avoid un-necessary stops on path for smooth riding.

So, here again we have 2 separate sets of sensors which sense cars coming and alert drivers with flashing lights. Like here sensor 1 and 2 sense car A and car B respectively and flash lights to alert both of them of each other. Hence, they will be already known to obstacles and slow down or move towards their own left-hand side in the lane to prevent collision.

4.3 CASE 3. Underground Parking slopes

Driving on slopes downwards or upwards both is a tough job and when a sudden turn after the slope or turn before taking the slope is a challenging job with anticipating of no obstacles in middle of path.
Conventional method is to employ a security staff to whistle and alert drivers. But due to human errors or miscommunication un-necessary stress comes to driving side. Being under stress or in anxiety accidents can take place and lead to property damage. Hence, a system needs to be provided to alert drivers to when to take in slopes to avoid confusions and un-necessary stress in them.

In this case for example refer figure 7. Here two different sets of sensors are provided to sense vehicles in their respective regions. Sensor 1 senses Car A and flashes light 1 to indicate a car coming down the slope to car B and similarly sensor 2 senses car B and flashes light 2 to indicate a car taking a turn to come up on the slope. Hence, both of them will be alert of each other and give way to each other or one will slow and stop until one pass by the path. Dippers and horns can be very effective too but due to human errors like not giving a horn or dipper and other errors like headlamp is fused and horns aren't working can create confusion and lead to a collision.



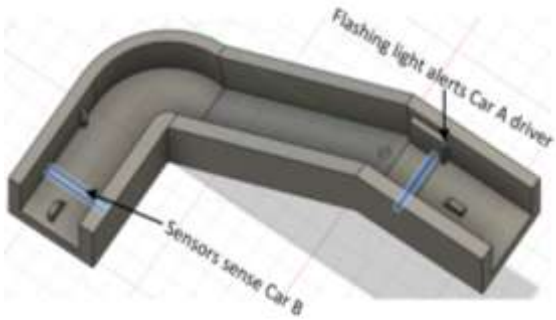


FIGURE 7. Sectional view from top of an underground parking

5. Summary of results for each case/Conclusion

5.1 Case 1. U-turns:
Without this sensing system the situation would be Car A will wait, judge the car coming if visible and take a U-turn. Car B will be aware of U-turn coming ahead with the symbols provided at the road ends but can only anticipate whether any vehicle will take a U-turn or there is no vehicle.
Hence, chances of collision are more.
So, if this sensing system is employed then both cars will be aware of each other and immediately react to situation much faster and easily since they are already aware.
For car A it will stop as soon as light blinks up and wait for the car at opposite lane to move away and then take a U-turn.
For car B it will slow down or change lanes to avoid collision or braking for efficient and smooth driving.
So, here a good amount of time is available to react and hence, make driving safer and smooth.

5.2 Case 2. Sharp bends or curves:
If the safety system is employed here, we see both the cars get aware of each other and react much earlier than the situation when they will be unaware of each other.
Later then sudden appearance of each other can lead to loss of control on wheels and later an accident.
So, here a better reaction time is possible since they will be already aware of upcoming obstacles and brake earlier than the situation when they are unaware of it.

5.3 Case 3. underground parking slopes:
If the safety system is provided here, we see that both of the cars are aware of each other and their paths.
Hence, they react accordingly to avoid collision and give way to each other by getting their cars closer to their left-hand side walls.
So, here there is no confusion among drivers and move in and out safely.
Also, there is minimal or no waiting of one car to pass by and wait for one's turn.
Safe and less time consumed for parking.
This system can be more reliable based on safety.
Other solutions maybe better at some cases but the proposed solution can be always safer.
The already available solutions are not found in all of the vehicles even its not possible to detect 2 wheelers or bicycle whereas the proposed solution can detect every obstacle in the path.
Just the solution isn't economic because every curve, underground paths, U-turns, etc. needs to have a sperate kit of sensors and Feedback LEDs.

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