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## AUTOMATED SYSTEM FOR DETERMINING SPEED OF CARS AHEAD

*Road accidents and speeding violations are pervasive issues that pose substantial threats to road users on a daily basis. In an ongoing effort to improve road safety and reduce the frequency of accidents, researchers and engineers have been dedicated to the development and implementation of new technologies. One such significant innovation is the utilization of speed control systems based on traffic cameras.*

*This paper delves into a thorough exploration of the pivotal role and significance of speed control systems on our roadways. It investigates the operational principles, advantages, and various strategies employed to enhance the efficiency of these systems, with the ultimate goal of achieving optimal results in speed control and ensuring road safety. Speeding remains a widespread concern that significantly contributes to road accidents. Such incidents lead to injuries, fatalities, and extensive property damage, underscoring the urgent need for effective speed control measures. Among the arsenal of solutions available, speed control systems utilizing traffic cameras have emerged as a prominent and promising approach. These systems function by monitoring and recording the speed of vehicles at specific locations, which is later used to enforce speed limits and penalize offenders. The advantages of speed control systems based on traffic cameras are multifaceted. They offer an objective and reliable method for detecting and documenting speeding violations, eliminating the need for law enforcement personnel to be present at all times. This aspect not only frees up law enforcement resources but also ensures consistent and unbiased enforcement of speed limits. Additionally, the data collected by these systems can serve as a valuable resource for traffic management, accident analysis, and road safety research.*

*Keywords: speed control system, traffic camera, road safety, speeding, road accidents.*

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## АВТОМАТИЧНА СИСТЕМА ВИЗНАЧЕННЯ ШВИДКОСТІ АВТОМОБІЛІВ, ЩО РУХАЮТЬСЯ ПОПЕРЕДУ

*Дорожньо-транспортні пригоди та порушення швидкісного режиму є поширеними проблемами, які щодня становлять серйозну загрозу для учасників дорожнього руху. У постійних зусиллях щодо покращення безпеки дорожнього руху та зменшення частоти аварій дослідники та інженери присвятили себе розробці та впровадженню нових технологій. Одним із таких важливих нововведень є використання систем контролю швидкості на основі камер руху.*

*Ця стаття детально досліджує ключову роль і значення систем контролю швидкості на наших дорогах. Він досліджує принципи роботи, переваги та різні стратегії, що використовуються для підвищення ефективності цих систем, з кінцевою метою досягнення оптимальних результатів у контролі швидкості та забезпеченні безпеки дорожнього руху. Перевищення швидкості залишається широко поширеною проблемою, яка значною мірою сприяє дорожньо-транспортним пригодкам. Такі інциденти призводять до травм, смертельних випадків і значної матеріальної шкоди, що підкреслює нагальну потребу в ефективних заходах контролю швидкості. Серед арсеналу доступних рішень системи контролю швидкості, які використовують камери дорожнього руху, стали видатним і багатообіцяючим підходом. Ці системи функціонують шляхом моніторингу та реєстрації швидкості транспортних засобів у певних місцях, що згодом використовується для дотримання обмежень швидкості та покарання порушників. Переваги систем контролю швидкості на основі відеокамер багатогранні. Вони пропонують об'єктивний і надійний метод виявлення та документування порушень швидкісного режиму, усуваючи необхідність постійної присутності правоохоронних органів. Цей аспект не тільки звільняє ресурси правоохоронних органів, але й забезпечує послідовне та неупереджене дотримання обмежень швидкості. Крім того, дані, зібрані цими системами, можуть служити цінним ресурсом для управління дорожнім рухом, аналізу аварій і дослідження безпеки дорожнього руху.*

*Ключові слова: система контролю швидкості, камера дорожнього руху, безпека дорожнього руху, перевищення швидкості, дорожні пригоди.*

### Introduction

On the modern roads, where road transport has become an integral part of life, ensuring the safety of all road users is one of the key tasks for states and bodies responsible for road traffic. Given the growing number of motor vehicles, it is necessary to constantly develop and implement new technologies that contribute to reducing the risk of traffic accidents and violations of traffic rules [1].

One of the promising solutions for controlling compliance with the speed limit on roads is the use of traffic camera systems. These systems, based on advanced technologies, provide effective traffic monitoring and detect violations such as speeding, which are certainly one of the most common causes of road accidents [2].

A continued focus on road safety is an important task, and effective speed control systems play an important role in achieving this goal. The use of advanced technologies and systems that allow accurate measurement of the speed of vehicles reduces the risk of accidents and contributes to the improvement of road discipline.

**Domain analysis**

Road speed is an important aspect of road safety, but the lives and safety of thousands of people are put at risk every day because of the unconscious attitude of some drivers to this aspect. Speeding is one of the most common and dangerous causes of road accidents, which leads to serious and tragic consequences for road users. [3].

According to the collected statistics (2011 - 2021), at least 25 percent of the total number of deaths and 10 percent of people injured in road accidents are due to speeding incidents. These statistics are detailed in Table 1 [4-5].

The data from the table were structured and displayed in the form of two diagrams in Figures 1 and 2 [5]. According to the charts presented about the number of people killed and injured in the world from 2011 to 2021 due to speeding, excessive speed has quite serious consequences. During the last decade, the number of people killed due to speeding has increased by 23% - from 10,001 people in 2011 to 12,330 people in 2021. In general, during the studied period, the loss of life due to speeding is approximately 29% of the total number of road accident fatalities, and the number of injured persons was also 13%. These are very alarming indicators that require immediate attention and action.

Table 1

**Killed and injured people due to speeding in 2011-2021**

Year	Number	Percent	Total	Number	Percent	Total
Killed			Injured			
2011	10 001	31	32 479	459 776	21	2 227 209
2012	10 329	31	33 782	502 846	21	2 369 083
2013	9 696	29	32 893	383 137	17	2 318 992
2014	9 283	28	32 744	339 189	14	2 342 621
2015	9 723	27	35 484	348 16	14	2 454 778
2016	10 291	27	37 806	376 914	12	3 061 885
2017	9 947	27	37 473	361 95	13	2 745 268
2018	9 579	26	36 835	358 924	13	2 710 059
2019	9 592	26	36 355	326 554	12	2 740 141
2020	11 258	29	38 824	308 013	13	2 282 015
2021	12 330	29	42 939	328 946	13	2 497 657



**Fig. 1. Percentage representation of killed and injured people due to speeding in 2011-2021**

Using the speed control system in a car is a key component of safe road operation and reducing road accidents. This system helps drivers maintain a safe speed and a safe distance from the vehicle in front by providing timely warning of dangerous distance, speeding or sudden braking.

Such speed control systems are becoming increasingly popular in the automotive industry as they demonstrate their effectiveness in preventing accidents and reducing injuries. They help drivers to become more attentive and responsible road users, and also contribute to the preservation of life and health of everyone on the roads [6]. The application of speed control systems is an important step towards achieving a safer and more stable road traffic, which is important for humanity.

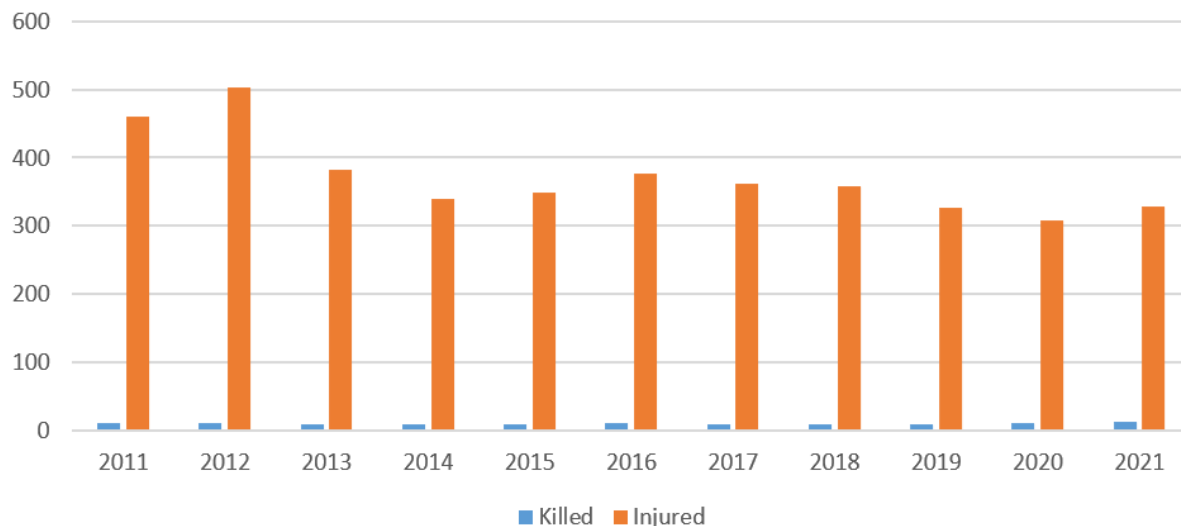


Fig.2. Quantitative representation of killed and injured people due to speeding in 2011-2021

### Analysis of existing solutions and technologies

Preventing road accidents and ensuring road safety is a priority for every driver. In this regard, within the framework of the development and improvement of vehicle safety systems, great attention is paid to ready-made solutions that are available on the market. Modern technological progress offers us a variety of systems that help monitor compliance with speed limits, record traffic situations and ensure the preservation of video with the prospect of use as evidence [7].

Overview of the ready-made systems will allow to understand their advantages and make a significant contribution to improving road safety and reducing the risk of road accidents:

1. *State speeding video recording system*

State speeding video recording systems, located on roads and highways, work on the basis of special cameras and sensors that record the movement of vehicles. Cameras can be placed on stationary posts or mobile devices. When a vehicle exceeds the set speed, the system automatically registers its license plate and time, and then generates a special ticket, which is sent to the owner of the vehicle by mail or email. The owner of the vehicle receives a notification of the violation and instructions to pay the fine. These systems help monitor compliance with speed limits on roads and ensure the safety of road users [8].

2. *Dashcam - an application for recording traffic violations*

Dashcam is an application that provides video from the car camera recording and stores it in the cloud. The application allows you to view recorded videos, download them to your computer or phone, and share them with others. To use Dashcam, you must first install the app on your phone or tablet. After installation, you need to create an account and connect the car camera to the application. After that, you can start recording the video. Dashcam allows you to record videos in Full HD (1080p) or HD (720p) quality. The app also allows you to adjust recording parameters such as video duration, resolution, and frame rate [9].

3. *Speedometer Pro*

Speedometer Pro is a mobile application that provides car speed tracking. The app is available for iOS and Android devices and displays the current speed, maximum speed, average speed, distance traveled and driving time. It is possible to view the history of tracking your own speed over a certain period of time [10].

After researching the available driver assistance systems and conducting the analysis, we can proceed to an in-depth comparison of these solutions. This process will allow us to uncover the unique characteristics of such systems, identify key benefits, and consider potential limitations. A comparison of the characteristics of the considered systems is presented in Table 2.

Table 2

**Comparison of already existing solutions for speeding control**

Characteristic	State speeding video recording systems	Dashcam	Speedometer PRO
Principle of the operation	Video recording of traffic violations using cameras installed on the roads	Video recording of traffic violations using cameras installed in the car	Tracking car speed using GPS
Accessibility	Available in all regions of Ukraine	Available for both - iOS and Android-based devices	Available for both - iOS and Android-based devices
Functionality	Tracking speeding, recording traffic violations, photographing traffic violations	Tracking speeding, recording traffic violations, photographing traffic violations, video recording	Speed tracking, speeding capture
Resource consumption	High	Medium	Low
Video quality	resolution up to 720p, frame rate up to 30 fps	resolution up to 1080p, frame rate up to 30 fps	Information is unavailable
Resource management	Automatic	Manual	Automatic
Advantages	High accuracy, the possibility of bringing violators to justice	High accuracy, the possibility of bringing violators to justice, the possibility of recording violations of traffic rules on roads where there are no cameras	High accuracy, the ability to control the speed of the car
Disadvantages	The cost of cameras installing	The cost of cameras installing	Impossibility of traffic rules violations recording
General impression	A successful system that helps make Ukrainian roads safer	A successful system that helps make Ukrainian roads safer	A successful system that helps drivers to control the car speed

Based on the comparison of existing systems, the authors propose to develop their own device, which will combine various functions from these systems, to increase safety and comfort on the road. Combining the features of existing driver assistance systems, our device will determine the speed of the vehicle in which the system is located, determine the speed of the vehicle ahead, collect information about cars violating traffic rules and take specific measures to punish offenders and keep other drivers on the road safe.

### **The operation of automated system for determining speed of cars ahead**

The system for determining the speed of the car in front can work as a separate link or as part of another system. As a separate component of the system, it increases vehicle safety by providing the driver with information about the speed of vehicles moving in front of him. This information helps the driver to respond in time to changes in the speed of other cars and ensures safer driving.

The system works according to the following algorithm: when the car engine is turned on, this system is turned on together with it. The first step is to find the cars ahead. At this stage, cars are recognized using the Gaar classifier method. The search is conducted until at least one vehicle is found. When a car is found, the system determines its coordinates and assigns an index (serial number) to it. For a given car, the distance traveled in a certain period of time is calculated and, based on this, its speed is calculated.

The next step is to track the detected car and its speed. This stage works while he is in the camera's field of view. If the car begins to brake and is at a short distance from the car in which the system is installed, the user will be notified of this by a special sound signal played from the speaker. This will focus the driver's attention on the situation on the road and give additional time to prevent a possible accident.

Also, when following a car, it may happen that it exceeds the permitted speed. In this case, the system will collect data about the violator and save it in the storage. At the same time, the user will have the opportunity to inform the law enforcement authorities about this event.

Every time the system identifies a new car, this algorithm is restarted. It is also provided for the simultaneous operation of the algorithm when recognizing more than one car.

The graphic representation of the abovementioned algorithm is presented in Figure 3.

For a detailed introduction to the operation of the car speed detection system, a parametric diagram was created (Figure 4). After recognizing the car in front, with the help of a cascade classifier, the coordinates of the car in the image are determined [11]. An integral step will be to determine the Y coordinate of the center of the car, to compare with the Y coordinates of lines A and B to determine the speed of the car. You also need to determine the time of crossing lines A and B, which will help determine the time the car travels the distance between them. The speed of the car will be calculated using the determined parameter of the distance between the lines and the passing time.

### **Experiments and directions of further work**

During the development of the speed detection subsystem, it was decided to conduct testing on video footage from a traffic camera.

During the experiments, it was found that for a more accurate measurement of the speed, it is necessary to reduce the resolution of the video stream. This will reduce the load on the microcontroller and allow more accurate determination of the car's position.

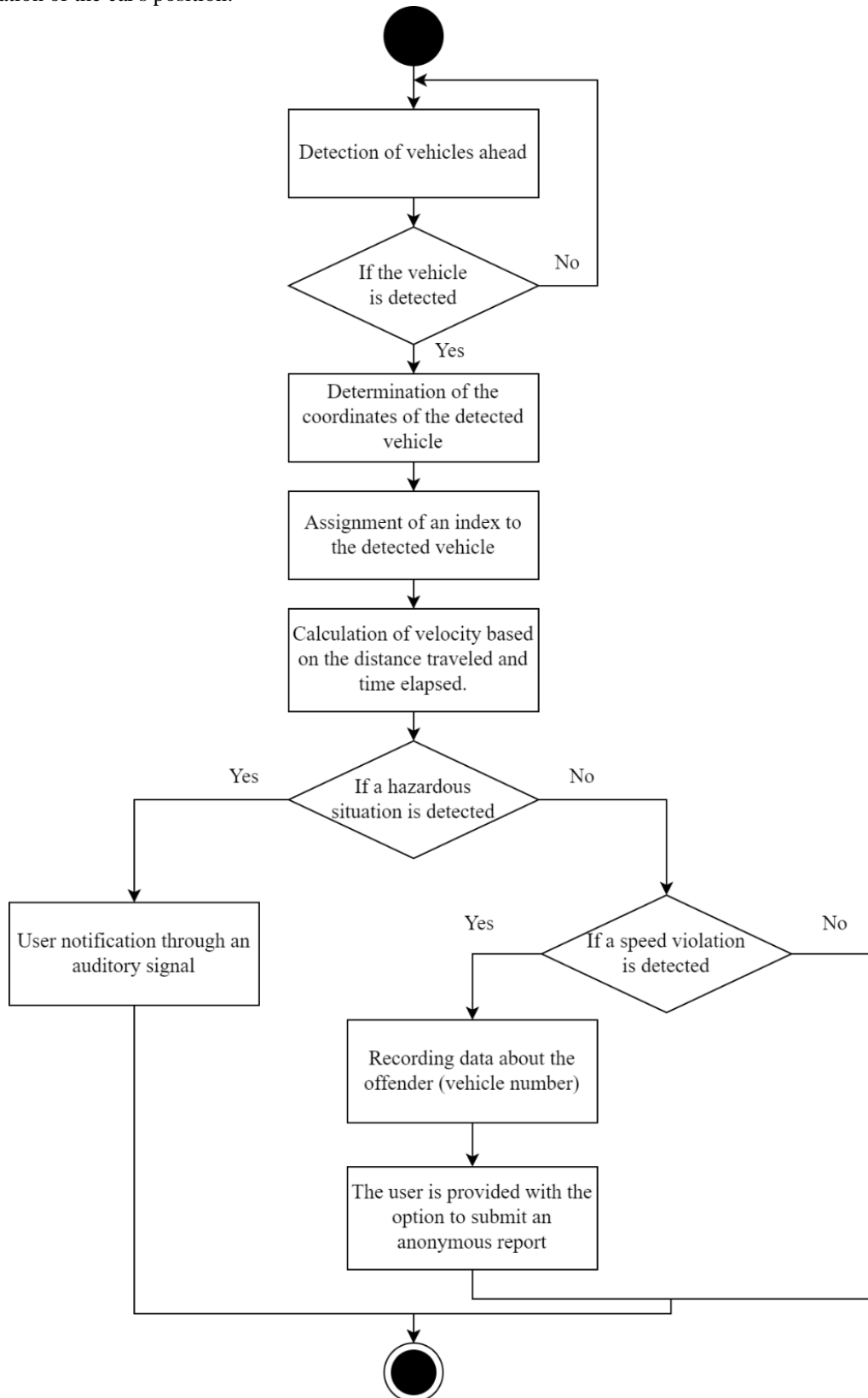
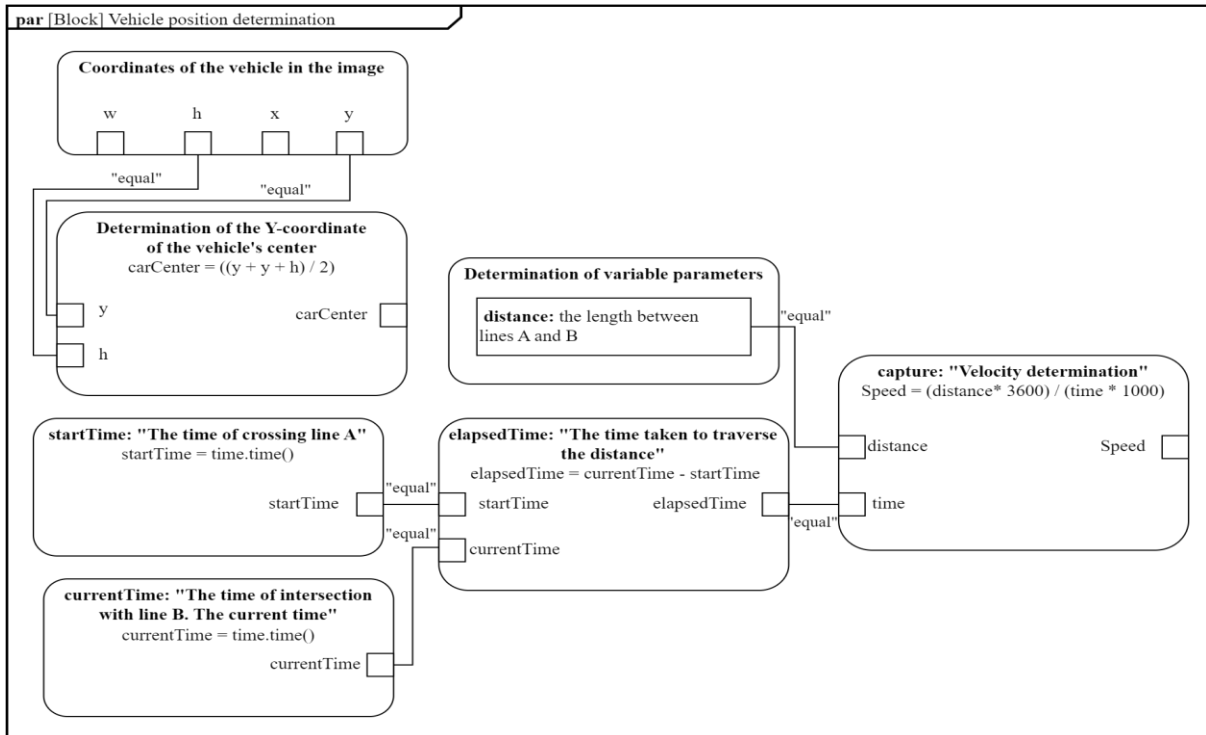


Fig.3. Graphic representation of the algorithm of the automated system for determining the speed of cars moving ahead

The test results are shown in Figures 5 and 6. They show the operation of the system, namely:

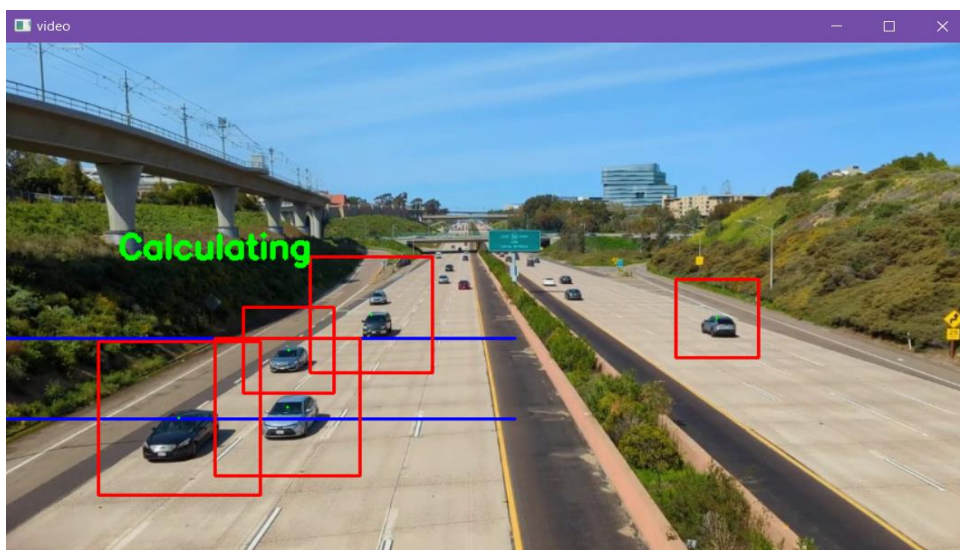
- display found cars;
- current state of the system ("Calculating");
- the position of two lines for measuring the time during which the car traveled the distance between them, on the basis of which the speed is measured;
- display of line B in green when a car crosses it;
- speed of the car when crossing line B.



**Fig.4. Parametric diagram of car speed determining**

To develop a vehicle speed detection device, the first step is to research the necessary functionality and requirements that are important for such a device. One of the important aspects of device development is ensuring high accuracy of speed determination. Accuracy in such a device is a critical factor, as inaccurate speed information can lead to dangerous situations on the road or false alerts to law enforcement.

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**Fig.5. Cars recognition in a video frame**



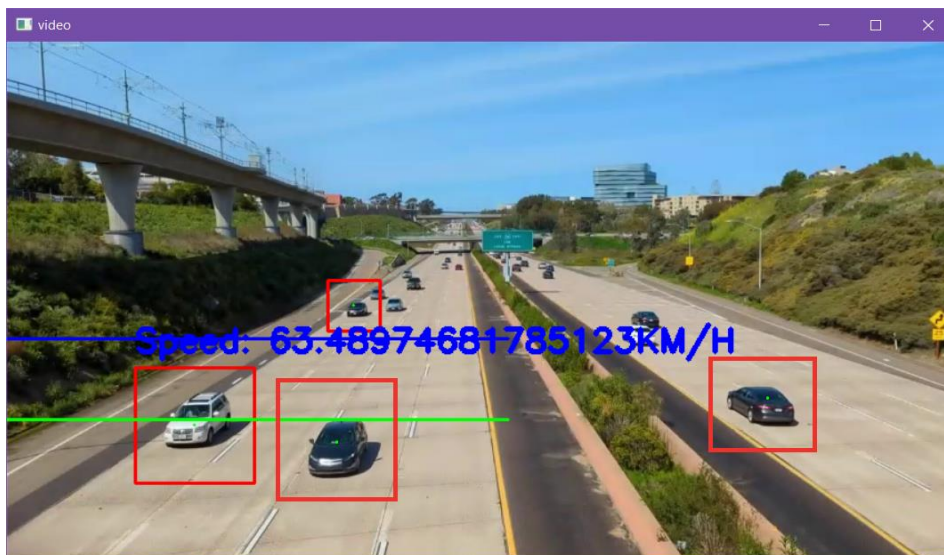


Fig.6. Crossing line B by car

As a result, certain requirements for the further development of the device were formed based on the main factors mentioned above:

- 1) increase in accuracy - research of new methods of speed measurement;
- 2) integration with other safety systems - compatibility of the device with other safety systems, such as stability control, automatic emergency braking, etc.;
- 3) data analysis and forecasting - using data analysis and AI to track various driver behaviors, assess risks and improve systems;
- 4) cooperation with law enforcement agencies - enabling the user to send information about violators of traffic rules to law enforcement agencies, which can potentially reduce the number of violators on the roads;
- 5) anonymity - ensuring the anonymity of the user when sending a message about an offense.

### Conclusions

Considering the statistics of the number of people killed and injured on the world's roads from 2011 to 2021, related to speeding, it is clear that excessive speed is a serious problem and affects the safety of road users. Over the past ten years, due to the increase in road traffic, the number of victims and victims of speeding accidents has remained high.

After analyzing the ready-made solutions, such as the state video recording system of speeding, Dashcam, Speedometer PRO, the disadvantages and advantages of these systems were taken into account and the work of the own system for determining the speed of the car in front was developed, which will combine various functions from these systems to increase the safety and comfort on the road. Combining the features of existing driver assistance systems, our device will determine the speed of the vehicle in which the system is located, the speed of the vehicle in front, collect information about cars violating traffic rules and will allow the user to send information to law enforcement agencies for the safety of other drivers on the road.

Taking into account the negative impact of speeding on road safety, it is important to actively promote the introduction of speed control systems in cars. These systems allow the car to determine the optimal speed and safe distance to the vehicle in front, as well as provide the driver with appropriate warnings of dangerous situations, such as speeding by the vehicle in front or sudden braking.

Implementation of speed control systems is a mandatory measure to improve road safety and reduce the number of traffic accidents related to non-observance of speed limits. Such technologies will help reduce the number of victims and injured on the roads, save the lives and health of road users and make the roads safer for everyone. Therefore, the use of a speed control system in cars is an important step in improving road safety.

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