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Classification of traffic signal system anomalies for environment tests of autonomous vehicles

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Abstract
In the future there will be a lot of changes and development concerning autonomous transport that will affect all participants of transport. There are still difficulties in organizing transport, but with the introduction of autonomous vehicles more challenges can be expected. Recognizing and tracking horizontal and vertical signs can cause ~~a~~ difficulties for drivers and, later, for autonomous systems. Environmental conditions, deformity and quality affect the perception of signals. The correct recognition results in safe travelling for everyone on the roads. Traffic signs are designed for people that is why the recognition process is harder for the machines. However, nowadays some developers try to create a traffic sign that autonomous vehicles can use. Computer identification needs further development, as it is necessary to consider cases where traffic signs are deformed or not properly placed. In the following investigation, the advantages and disadvantages of the different perception methods and their possibilities were gathered. A methodology for the classification of horizontal and vertical traffic signs anomalies that may help in designing better testing and validation environments for traffic sign recognition systems in the future was also proposed.

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1. Introduction

The purpose of creating autonomous vehicles is to reduce and prevent accidents and ensure safe travel for all participants. This is only possible if self-contained vehicles in the traffic accurately detect the signals placed around them and respond appropriately to them. Human drivers may cause an accident if they misinterpret or fail to detect a traffic sign and the road signs or do not follow the track. These cases must be completely impossible with autonomous systems by improving the accuracy of recognition software (Pintér et al., 2017).

The article draws attention to various anomalies in transport. Visibility and weather, as well as different situations on the road also affect the ability of both drivers and autonomous vehicles to recognize signs. The mistakes collected here will help avoid future problems that may make it difficult to recognize traffic signals. There are horizontal and vertical signs on the roads. The article focuses on vertical and horizontal signs (traffic signs, traffic lanes) and their disadvantages.

2. Parameters for traffic signals

Traffic signs are inevitable for modern infrastructure as old vehicles are involved in traffic, so it is crucial to solve detection problems. Traffic lanes are also needed because they help ~~a~~ vehicle to track the specified A-point to the B-point. Traffic signs and lanes play an important and decisive role as they determine traffic on the road, depending on their type (danger, warning, information, track, etc.). Hardly ever does a road section exist, where no sign can be seen. Horizontal and vertical signals provide information in different ways. In addition to signs, road users are provided with information on traffic sign's and road marking's shape, colour, length and position. Due to their importance, traffic signs and lanes have to comply with many standards and specifications that are included in a technical specification of a road. Each group applies to specific rules, including their shape, dimension, surface, colour, and lighting properties. Moreover, there are some rules on the colours, length, shape, and other parameters of a traffic bar. Like in the case of other markings, there are strict safety requirements that include strength, and strength properties apart from the size range must be taken into account (Figure 1).

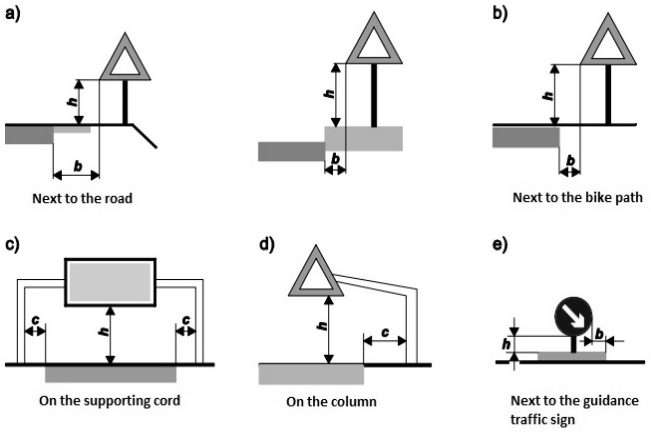

Fig. 1. Heights and length parameters of traffic signs *(ROAD TECHNICAL SPECIFICATIONS E-UT-04-02-11-2012-ROAD SIGNS (T) DESIGN, APPLICATION AND PLACEMENT OF SIGNBOARDS)*

Drivers receive a lot of information and external stimuli during travel, so traffic signals need to be organized in such a way that drivers can interpret them and respond to them. (Stallkamp et al., 2016)

In traffic signs, a particular attention must be paid to ambient conditions which may have disturbing effects on light, as well as other factors (trees, bushes, columns or other boards). If the area has public lighting, the nearby traffic sign must be located in clearly place. When installing illuminated signs, it needs to be certain that the visibility of other illuminated signs in their environment does not deteriorate.

Traffic lanes of length, shape, and colour help define the track, which can be followed by an autonomous vehicle. There are many forms, signs and material bands on the way with lots of information. The use different types of track and road signs for road construction is presented in Figure 2.

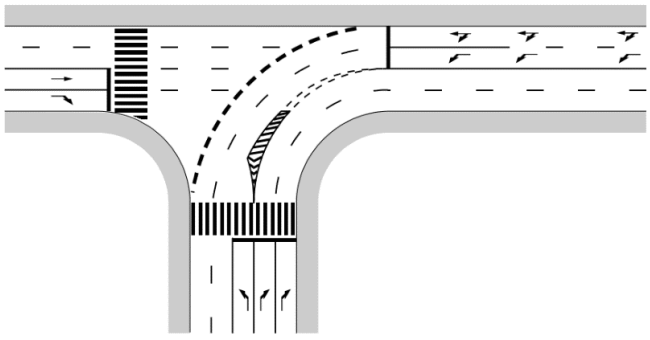

Fig. 2. Road markings and lanes on the roads. *(ROAD TECHNICAL SPECIFICATIONS E-UT2-1.113-2001-DESIGN OF ROAD MARKINGS)*

These factors can be of great help for autonomous systems in the perception of the traffic signs later.

3. Problems with badly placed vertical and horizontal traffic signs

The lack of visibility, mistakes, shadows, divergent and contradictory placement may cause misunderstandings and accidents. Human drivers are able to overcome these hard situations by making an independent decision. However, recognition systems only address the situations they are taught prepared for (Stallkamp et al., 2016; Evtimov et al., 2017).

3.1. Anomalies of traffic signs

Once they have been collected, cases from various traffic signals that can be integrated into a simulation phase of the test, and an autonomous systems can be created. The first step in teaching is to classify the errors, visibility, lightness, recognizability, position and complexity of the traffic signs and road markings at the permitted speed (Nyerges and Szalay, 2017).

Visibility is the ability or inability to see a sign when it is covered by a tree, bush or column, clarity is whether or not one can see a traffic sign – a clean or a dirty one, while recognisability is when one can recognize a traffic sign by its form, colour and stickers. The position means that the sign is not at the right height or has fallen. Simplicity when too much or opposite information should be observed. Nowadays the hardest thing to recognize is the deformation (Barria and Thajchayapong, 2011).

Recognizing and responding to signals further complicates traffic limitations for each road segment. In such cases, autonomous vehicles must recognize signs for camera recognition and other support systems. Assistance should be provided to ensure access to the area. The figure below shows that when a badge is badly placed and the drivers or the recognition system cannot see the signs because of the position (Figure 3).

Fig. 3. Recognition system cannot see the signs, because of the position

The size and length of the text should be readable from a distance. The amount of information includes the number of traffic signs placed on a column one under another.

Understanding signs is difficult if the information on the board does not appear. This may be due to poor quality and condition. The next bigger traffic sign is, in many ways, a good example of what the factors that can disturb and make drivers uncertain are (Fig. 4).

Fig. 4. This traffic sign is hard to understand and can disturb drivers

It is necessary to present the achieved results of the research illustrating them with Tables, pictures, diagrams and giving in details relations between the stated facts. That section should have a character of a scientific discussion that would confirm or exclude the data known from the literature.

Only a limited quantity of information on the signs can be detected and interpreted in a short time by the driver. Excessive and unclear information may be a problem for autonomous vehicles as well as responding to many signals simultaneously. In many places custom-designed boards are used, which will be meaningless for autonomous vehicles due to excessive information (Figure 5).

Fig. 5. This traffic sign is hard to understand and can disturb drivers

3.2. Anomalies of traffic lanes and road markings

The road markings and traffic lanes have a lot of faults when the workers do not use them normally in the construction area. The shape of the temporary road signs must be the same as the shape, colour, dimensions and, in some cases, the layout of the permanent signals. Temporarily used road markings indicate the course in two ways, depending on the type of work, budget, length, and duration that you is used. Signs can be painted or glued with prefabricated elements. Deviation from individual symbols (arrows, inscriptions) is permitted if it can be fixed with fastenable tapes for faster and more economical execution.

It is expensive to buy, but in the case of durable jobs it is a more permanent and reliable solution. The advantages of glued symbols are that they are more economical, faster and easier to apply to the surface, but have a significant disadvantage that they differ more frequently from the original location due to the road surface and the weather conditions. In many cases, it may cause an accident if all lanes and road signs "slip" from the original location.

It is important for car drivers to notice traffic lanes and road markings in time. As soon as drivers go in the right lane, the better they can prepare for the situation. Often, it were not started early enough or the signs were not clear and visible, so traffic information was unexpected for human drivers.

Removing temporary marks with staining also causes problems. Workers who handle the restrictions are grey, which does not completely erase the provisionally used signal. This often causes misunderstandings for drivers and other participants of the traffic.

Fig. 6. The Use two types of traffic lanes and misunderstandings it causes

The third problem occurs when new lanes and markings are placed directly on old ones, as the Figures below show (Fazekas and Gáspár, 2015).

Fig. 7. Glued traffic markings used with old ones still visible

The interpretation of traffic signs for people and systems is not an easy task, so there will be continuous improvements in the future so that no further accidents occur.

4. New opportunities concerning traffic signals in the future

Recognition of signs is also influenced by weather, environmental conditions, visibility, and noticeability. This makes it difficult for the detection systems to function properly and can cause an accident in case of misrepresentation. Camera-based detection is therefore unreliable and requires the use of another detection system, LIDAR, which makes the system redundant. Later, the RADAR may also be used to locate the signals.

When testing autonomous systems, it is important to address them in such a way as to detect shortcomings and malfunctions as soon as possible (Szalay et al., 2017).

There is also a test of other environment detection methods besides the cameras. For example, LIDAR, which uses laser radiation, which forms points of cloud. In the environment created by the laser scanner, brighter objects are more difficult to see. They tried to detect the disc in a bad weather with a laser. The following pictures show the result. On the first picture, he could perceive the outline of the traffic signs. The second misinterpreted the signals, and in the third picture he could not recognize it at all. From this it can be stated that the laser may be suitable for detecting, but it cannot help the camera with accurate recognition (Figure 8) (Landaa and Prochazkaa, 2014; Lasota and Skoczylas, 2016).

Fig. 8. Using LIDAR detection for different traffic signs (Landaa and Prochazkaa, 2014)

The other option to help when autonomous vehicles must know about locations. New signs help self-driving vehicles with the orientation on the A9 road Munich-Nuremberg. Autonomous vehicles can determine their exact location with the so-called landmark signs, as the Federal Ministry of Transport announced in Berlin. This sensor is a state-of-the-art sensor technology and a centimetre-accurate digital map. The new signs are another building block on the way to the first fully digitalized and fully networked road. The signs with geometric figures on a black circle are built around the motorway junction Holledau on the A9 and the A93 towards Regensburg at a distance of about 2.5 kilometres. For human drivers have no meaning but it helps in the future transport (Fig. 9) (Potó et al., 2017).

Fig. 9. Using Autonomous vehicles can independently determine their exact location with the so-called landmark signs

Visibility is worse when environmental conditions are bad, and it is hard for the humans, further deteriorates perception. Night, rain and fog make it difficult to notice signs. Therefore, there is a need for additional support systems that eliminate these weaknesses and use other objects for localization (Dpa/Muenchen.De).

5. New opportunities concerning traffic signals in the future

The classes of the mistakes: ***the quality, status, quantity, visibility, perception, recognizability, clarity, and interpretability of the boards at the permitted speed.***

In order to prevent accidents, the classification system would help to evaluate traffic signals based on different aspects. In each classification, each attribute receives a value. The evaluation can be used for all signals. The following table contains both the attributes and values.

Table 1. Example

	Visibility 1= not visible 5= visible	Clarity 1= dirty 5= clear	Recognizability 1= not recognizable 5= recognizable	Position 1= Improper 5= standard	Simplicity 1= complex 5= simply
Fig.2.	1	4	2	2	3
Fig.3.	5	2	2	4	1
Fig.4.	5	5	5	5	1
Fig.5.	2	2	1	4	1
Fig.7.	5	5	3	5	5

The system can be developed to configure anomalous table installation on an autonomous vehicle test site, thus helping in the identification of recognition system weakness.

6. Conclusion

The result of this article is a description of the recognition difficulties associated with traffic signs, lanes, and road signs. Problems raised may help in the development of recognition systems or the search for a new support system and test method. Development will help to make the system more accurate to better understand the environment, thereby preventing certain accidents.

Based on the results of the previous tests, the LIDAR system supports camera-based recognition in such a way that the shape of the signals can be identified in the appropriate environment and visual conditions. However, the laser cannot accurately determine and occasionally erroneously detect traffic signals and RADAR helps locate the signals.

Before it is developed, the cases and circumstances that can help you test your system must be gathered which will enable to create a system that recognizes an environment that knows its limitations and weaknesses.

Zalaegerszeg is currently setting up a test track for highly automated and autonomous vehicles (ZalaZONE). Vertical and horizontal traffic signs disorders contribute to the realization of such a test environment where traffic signal recognition systems can be effectively tested and validated safely. After protocols, the systems will allow safe traffic in the future.

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自治车辆环境试验交通信号系统异常分类

關鍵詞
分类
交通信号系统
异常
自动驾驶汽车
测试环境

摘要
未来将会有很多关于自动运输的变化和发展，这将影响所有运输参与者。组织运输仍然存在困难，但随着自动驾驶汽车的引入，可以预期会遇到更多挑战。识别和跟踪横向和纵向标志可能会给司机和后来的自动化系统带来困难。环境条件，畸形和质量都会影响信号的感知。正确的识别结果为道路上每个人的安全旅行。交通标志是为人们设计的，这就是为什么识别过程对于机器来说更难。但是，现在一些开发商尝试创建自动驾驶车辆可以使用的交通标志。计算机识别需要进一步发展，因为有必要考虑交通标志变形或放置不当的情况。在接下来的调查中，收集了不同感知方法的优缺点及其可能性。还提出了一种分类水平和垂直交通标志异常的方法，可能有助于为将来的交通标志识别系统设计更好的测试和验证环境。