

## Violence Detection on Board of Shared Autonomous Vehicles: A Literature Review

Raufi F. Stella<sup>1\*</sup>, Camila de Sousa Pereira Guizzo<sup>2</sup>, Xisto Lucas Travassos<sup>3</sup>

<sup>1</sup>Product Development, Ford Motor Company; <sup>2</sup>Programa de Modelagem Computacional e Tecnologia Industrial, SENAI CIMATEC University Center; Salvador, Bahia; <sup>3</sup>Federal University of de Santa Catarina; Joinville, Santa Catarina; Brazil

This paper presents proposals for technological solutions to previously detect violence among passengers of a shared autonomous transport mode. By analyzing the Design Science Research method and the conjectural behavior of the population, the problem contextualization about the safety of public transport can be determined in terms of violence. So, a product meant to detect violence is proposed in this study. Product design proposals, based on artificial intelligence, are described within. We concluded that this subject is relevant and demands more attention to support the public acceptance of autonomous vehicles (AVs), and shows there are existing solutions that can be adapted to fulfill the needs of this specific usage.

**Keywords:** Surveillance. Safety. Shared Autonomous Vehicle. Violence. Detection.

### Introduction

Urban areas will concentrate at least 60% of the world population until 2030 [1]. The increase in the urban population will put a strain on the current public transportation system. To prevent this fact and provide sustainable growth, United Nations (UN) has established ambitious targets for the beginning of the next decade. These targets call for valuable transport systems for everybody that will have to be affordable, accessible, safe, and sustainable. This will improve road safety, as well as provide for people who need special attention, such as people in vulnerable situations, people with disabilities, the elderly, women, and even children.

There are several work streams in place to propose solutions for urban mobility in the future. One of them is the race for the development and implementation of autonomous vehicles, which promise to minimize the traffic chaos in big cities [2]. It has been said that urban transportation will face three revolutions in the form of fleet electrification, automation, and ride-sharing [3]. Those will translate to less pollution, less traffic,

and better use of the vehicle fleet. The fully self-driven vehicles, with level 5 autonomy [4], will have a highly beneficial impact on the lives of people who are not eligible for driving. It was also demonstrated that when more shared autonomous vehicles are used; more benefits for the population exist. That means by having mobility as a service in place, creates an environment where vehicles don't pollute and are fully shared, as well as integrated into other transportation modes [5]. Incentivizing the population to use shared transport is a key priority for a public administration that aims to improve urban mobility and consequently, some hostile problems must be faced and reduced. Sexual harassment is a reoccurring and worrying issue on public transportation and is typically against women [6]. The integration of various modes of transportation during a unique trip makes the user more exposed to violence when transferring from one mode of transportation to another [7]. Besides that, emerging countries like Brazil are experiencing rising levels of violence in big urban centers [8].

So far, tests with self-driven vehicles have been performed in developed countries only. Although there are still many constraints to be solved, such as legislation, privacy, cybersecurity, vehicle to vehicle, vehicle to infrastructure connection, and others; sooner or later, autonomous vehicles are going to hit the roads, and spread out into the world. The point is that safety issues related to violence are mostly present in emerging countries,

Received on 18 January 2022; revised 28 April 2022.

Address for correspondence: Raufi F. Stella. Via Atlântica, BA 530, Km 2,5. Camaçari- BA- Brazil. Zipcode: 42810-440. E-mail: rstella2@yahoo.com. DOI 10.34178/jbth.v5i2.216.

J Bioeng. Tech. Health 2022;5(2):155-159.  
© 2022 by SENAI CIMATEC. All rights reserved.

and maybe overseen by the developers of this new disruptive technology.

### Problem Contextualization

In a near future, solutions for urban mobility will be at the forefront; therefore, a trend of stakeholders such as academy researchers and car manufacturers will be betting on the shared autonomous vehicle as a strong competitor. The fact is that, beyond congestion problems, the high population density in big cities will worsen safety and security issues for the population. If we compare an autonomous vehicle to a vending machine, we may see that a surveillance safety system should be in place to inhibit the action of criminals. Today's public transportation system is not perfect, but the simple aspect of having more people around may help in terms of law and order, even if it is a single bus driver.

Thus, the pain point is the vulnerability of the passengers of a shared autonomous vehicle transportation service in terms of violence.

### Research Question

What is the existing literature regarding violence detection technologies that could contribute to the development of a surveillance system to be implemented on shared autonomous vehicles?

### Research Objective

This study aims to identify the state-of-the-art technologies, which are treated as potential features of the proposed artifact and fulfill the requirements to meet the expected function.

### **Material and Methods**

The method used is based on the Design Science Research Model (DSRM), which is a variation of the Design Science Research (DSR), as a means of practicing scientific research through the development of an artifact. DSR may have

either the approach of generating technical and scientific knowledge or developing an artifact to solve a problem. DSRM follows the foundation of DSR and states that the development of an artifact has to be grounded on the conjectural behavior of people in terms of how they learn, work, and communicate. This conjectural behavior is then applied to the development of such an artifact, which is meant to solve an existing pain point that may bother those people (Figure 1) [9].

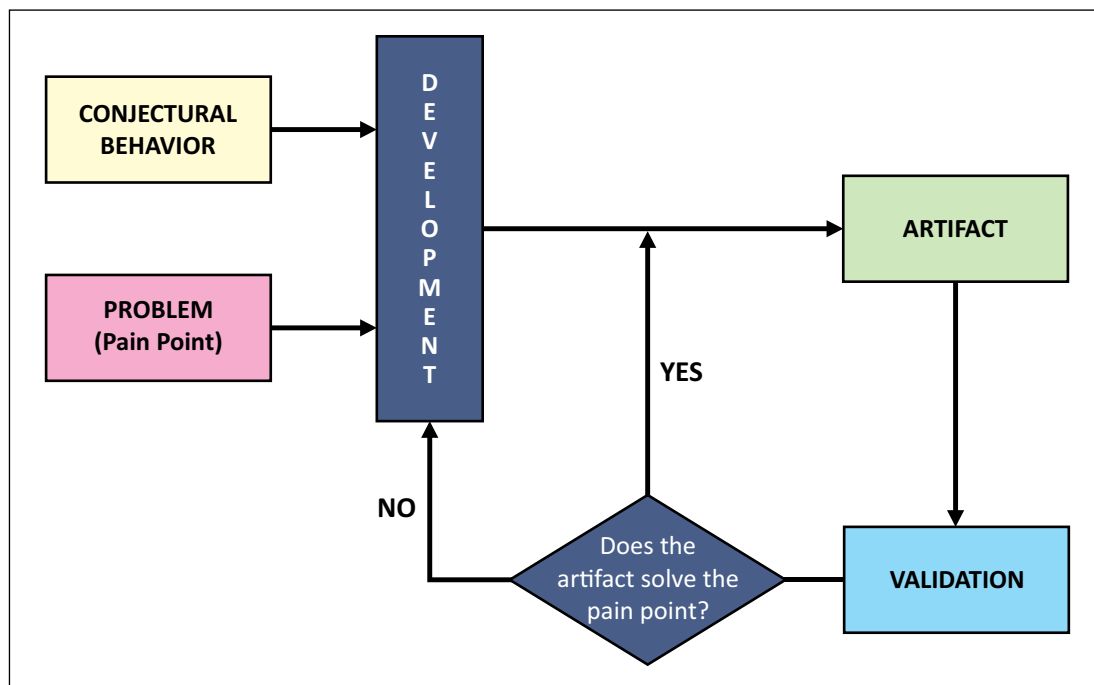
DSR is largely used in the information systems (IS) field, leading to either scientific or technical knowledge or both. The first step in a DSR is the literature revision. In addition, being the artifact novel and useful, thus it contributes to design knowledge [10].

Being a qualitative type study, the present research aims to seek information about a supposed artifact that will minimize the pain point of a group of people by proposing solutions to answer the research question.

### Research Parameters

Only recent papers from 2019 to 2021 were selected, according to the following search string applied: (Surveillance), AND ("Violence detection"), AND (Safety), AND ("Shared Autonomous Vehicle") OR ("Autonomous vehicle") OR ("Self-driven vehicle"), AND (Violence) OR (Harassment) OR ("Sexual abuse"). The usage of punctuation such as commas, inverted commas, brackets, and the prepositions AND, OR were necessary to restrict the search of papers related to some kind of violence, which were also related to the new technology of the shared autonomous vehicles, which can also be found with the terminology of self-driven vehicles. The data banks used for information research were:

- Google Scholar (<https://scholar.google.com>)
- Science-Direct Elsevier (<https://www.sciencedirect.com>)
- IEEE Xplore Access Digital Library (<https://ieeexplore.ieee.org>).

**Figure 1.** Design Science Research Model (DSRM).

Source: Adapted from Pimentel and colleagues [9].

The search resulted in only eleven papers, which suggests that the subject violence detection referred to shared autonomous vehicles is still limited. These papers were evaluated, and only two were relevant to autonomous vehicles. This drove the author to search for more information in papers related to violence detection in general, with a focus on recent smart technology studies. As said, a new round of research was conducted, using the same data banks, and at that time eliminating the following terms from the previously used search string: (“Shared Autonomous Vehicle”) OR (“Autonomous vehicle”) OR (“Self-driven vehicle”). This new search came up with more results, which were sorted by relevance and affinity to the artifact subject of this paper, which allowed the author to get more information about state-of-the-art technologies applied to surveillance systems.

## Results and Discussion

### Conjectural Behavior

Human aggression may be interpreted following either an evolutionary or a psychological approach and comprehended because of natural selection, or as a consequence of the behavior learned during childhood, respectively. While the function of an aggressive act falls into two categories: resource competition and reaction to danger. Nevertheless, both approaches overlap each other in several ways, and so the motivation for the aggression may be understood under the frustration-aggression hypothesis, where frustrations can create aggressive behaviors [11,12]. The meaning of the term aggression is a subject of many discussions, and one suggestion defines it as, any kind of behavior expressing the goal of harming or injuring another person, who oppositely

is motivated to react back to avoid that [13]. An aggressive action can be translated into violence, which can be expressed physically, verbally, or indirectly. This study explores the first two, while the third is more related to social manipulation. Furthermore, the study illustrates that alcohol and illicit drugs are considered catalyzers of violence [14,15]. The consequential effects can be classified into three categories: visual (facial expression, body language); auditive (linguistic speech, paralinguistic speech); and physiological (skin temperature, respiratory rate, brain activity; heart rate) [16].

### Design Concept of the Artifact

An artifact capable of identifying physical and verbal violence among passengers of a shared autonomous vehicle transport system. The artifact was split into two portions, being: hardware and software.

#### *Hardware (sensors)*

Thermal cameras are more appropriate to monitor violent movements once they are not dependent on luminosity [17]. These same cameras can also monitor the passengers' temperature. Voice recognition techniques are also abundant, and microphones can be easily adapted to the interior of a vehicle. However, the location of the microphones may have to be tuned. Doppler radars might also be used to can monitor heart rate at distance. The challenge arises in detecting alcohol and illicit drugs are more difficult to be detected in a fast way and without more invasive methods. The behavior of the drug user can express or perhaps suggests the presence of these substances in his body.

#### *Software*

Violent activities can be detected using computer vision techniques by analyzing the images of surveillance cameras and then

extracting information such as acceleration, flow, appearance, time, etc. The methods used may vary and are in a continuous improvement process in terms of performance, accuracy, and efficiency. Simply put, the steps of the process are:

- Extraction of the data from the images or videos;
- Preprocess of the data;
- Transformation of it into fragments;
- Extraction of the features to be used (motion, speed, acceleration, optical flow, time);
- Transformation of the data into the format to be fed to the Artificial Intelligence (AI);
- Evaluation of the data through the AI;
- Checking the accuracy;
- Presentation of the result.

The AI used can be based on techniques such as Machine Learning, Support Vector Machine, and Deep Learning [18].

Due to privacy restrictions regarding video recording and transferring of data, patches on the images might be needed to avoid the identification of the occupants. Unfortunately, this deteriorates the capacity of the software to detect emotions or other important information. To overcome this issue, techniques for generating facial anonymization have been proposed [19].

### **Conclusion**

Aggressiveness is somehow present in human beings and depending on the person, and the surrounding environment it can turn into violence. The goal is to detect the possibility of an incident, but if it cannot be avoided, it is desirable to collect and provide evidence of a crime. Besides violence detection in terms of the safety of the passengers, it's important to think about a surveillance system also aimed at the security of goods and other products that may be delivered by a transportation system based on autonomous vehicles. As in any other surveillance system, legal terms of the local legislation regarding privacy aspects must be observed and evaluated.

Even though the literature about violence detection onboard autonomous vehicles is still rare, the literature about violence detection itself is very vast, which suggests there are many opportunities about adapting these already known technologies to the AVs.

### Acknowledgments

The author would like to thank Ford Motor Company for the opportunity to publish his work.

### References

1. ONU. 2021. Available in: <<https://www.un.org/en/>>. Accessed in: 10 April 2021.
2. Lanhang YE, Yamamoto T. Evaluating the impact of connected and autonomous vehicles on traffic safety. *Physica A: Statistical Mechanics and its Applications* 2019;526:121009.
3. Fulton LM. Three revolutions in urban passenger travel. *Joule* 2018;2(4):575–578.
4. SAE. 2021. Disponível em: <<https://www.SAE.org/>>. Accessed in: 10 Aug 2021.
5. Agriesti S et al. Impact of driverless vehicles on the urban environment and future mobility. *Transportation Research Procedia* 2020;49:44-59.
6. Orozco-Fontalvo M et al. Women's perceived risk of sexual harassment in a Bus Rapid Transit (BRT) system: The case of Barranquilla, Colombia. *Journal of Transport & Health* 2019;14:100598.
7. Caires, FOC, Santos GF. A Geografia do crime e os efeitos do metrô sobre assaltos a ônibus na cidade de Salvador. In: XVII Encontro Nacional da Associação Brasileira de Estudos Regionais e Urbanos. Rio de Janeiro, XVII ENABER, 2019.
8. Cerqueira DRC et al. Atlas da violência 2020.
9. Pimentel M, Filipo D, Santos TM. Design Science Research: pesquisa científica atrelada ao design de artefatos. *RE@ D-Revista de Educação a Distância e eLearning* 2020;3(1):37-61.
10. Baskerville R et al. Design science research contributions: Finding a balance between artifact and theory. *Journal of the Association for Information Systems* 2018;19(5):3.
11. Berkowitz L. Frustration-aggression hypothesis: examination and reformulation. *Psychological Bulletin* 1989;106(1):59.
12. Archer J. The nature of human aggression. *International journal of law and psychiatry* 2009;32(4):202-208.
13. Baron RA, Richardson DR. *Human aggression*. Springer Science & Business Media, 2004.
14. Chermack ST, Giancola PR. The relation between alcohol and aggression: An integrated biopsychosocial conceptualization. *Clinical Psychology Review* 1997;17(6):621-649.
15. Abdalla RR et al. Association between drug use and urban violence: Data from the II Brazilian National Alcohol and Drugs Survey (BNADS). *Addictive Behaviors Reports* 2018;7:8-13.
16. Osman ALH, Falk TH. Multimodal affect recognition: Current approaches and challenges. *Emotion and Attention Recognition Based on Biological Signals and Images* 2017:59-86.
17. Zizi TKT et al. Aggressive movement detection using optical flow features based on digital & thermal camera. In: *Proceedings of the 6th International Conference on Computing and Informatics*. 2017:256-261.
18. Ramzan M et al. A review on state-of-the-art violence detection techniques. *IEEE Access* 2019;7:107560-107575.
19. Mishra A, Cha J, Kim S. HCI based in-cabin monitoring system for irregular situations with occupants facial anonymization. In: *International Conference on Intelligent Human Computer Interaction*. Springer, Cham 2020:380-390.