

VIOLENCE DETECTION ON BOARD OF SHARED AUTONOMOUS VEHICLES: A LITERATURE REVIEW

Raufi F Stella^a, Camila de Sousa Pereira Guizzo^b, Xisto Lucas Travassos^c

^a, Product Development, Ford Motor Company, Brazil.

^b, Programa de Modelagem Computacional e Tecnologia Industrial, Centro Universitário Senai Cimatec, Brazil.

^c Universidade Federal de Santa Catarina, Campus Joinville, Brazil

Abstract: This paper presents proposals of technological solutions addressed to detect violence among passengers of a shared autonomous transport mode. Through analyzing the Design Science Research methodology and the conjectural behavior of the population, the problem contextualization about the safety on public transport can be determined in terms of violence. So, we proposed a product meant to detect violence based on the product design proposals based in artificial intelligence by literature review. The subject is relevant and demands more attention to support the public acceptance of autonomous vehicles (AVs), and shows there are existing solutions which can be adapted to fulfill the needs for this specific usage.

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

UMA REVISÃO DA LITERATURA A RESPEITO DE DETECÇÃO DE VIOLÊNCIA A BORDO DE VEÍCULOS AUTÔNOMOS COMPARTILHADOS

Resumo: Este artigo visa propor alternativas de soluções tecnológicas voltadas à detecção de atos violentos entre passageiros de veículos autônomos de transporte compartilhado de passageiros. Baseado na metodologia de “Design Science Research (DSR)”, as conjecturas comportamentais da população, no quesito violência, determinam o problema do contexto, acerca da segurança no transporte coletivo, e para tanto são propostas alternativas do produto, detector de violência. Neste estudo são expostas soluções baseadas em inteligência artificial, já validadas em outros contextos. Conclui-se que o tema é relevante e demanda de mais atenção para ajudar na aceitação dos veículos autônomos por parte da população, e que já existem soluções que possam ser adaptadas para esse uso específico.

Palavras-chave: Vigilância; Segurança; Veículo autônomo compartilhado; Violência; Detecção.

1. INTRODUCTION

It is expected that at least 60% of the world population will be concentrated in urban areas by 2030 [1]. Consequently, this increase in the urban population will put a strain on the current public transportation system. To prevent that, and provide a sustainable growth, United Nations (UN) has established ambitious targets for the beginning of the next decade. These targets call for valuable transport systems for everyone; systems 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 development and implementation of autonomous vehicles, which promise to minimize the traffic chaos in the 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 a better use of the vehicle fleet. The fully self-driven vehicles, 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, it creates an environment where vehicles don't pollute, are fully shared, as well as integrated into other transportation modes [5].

Incentivizing the population to use shared transports 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, and 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, and may be overseen by the developers of this new disruptive technology.

1.1. Problem contextualization

In a near future, solutions for urban mobility will be in 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.

1.2. 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?

1.3. 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 necessary requirements to meet the expected function.

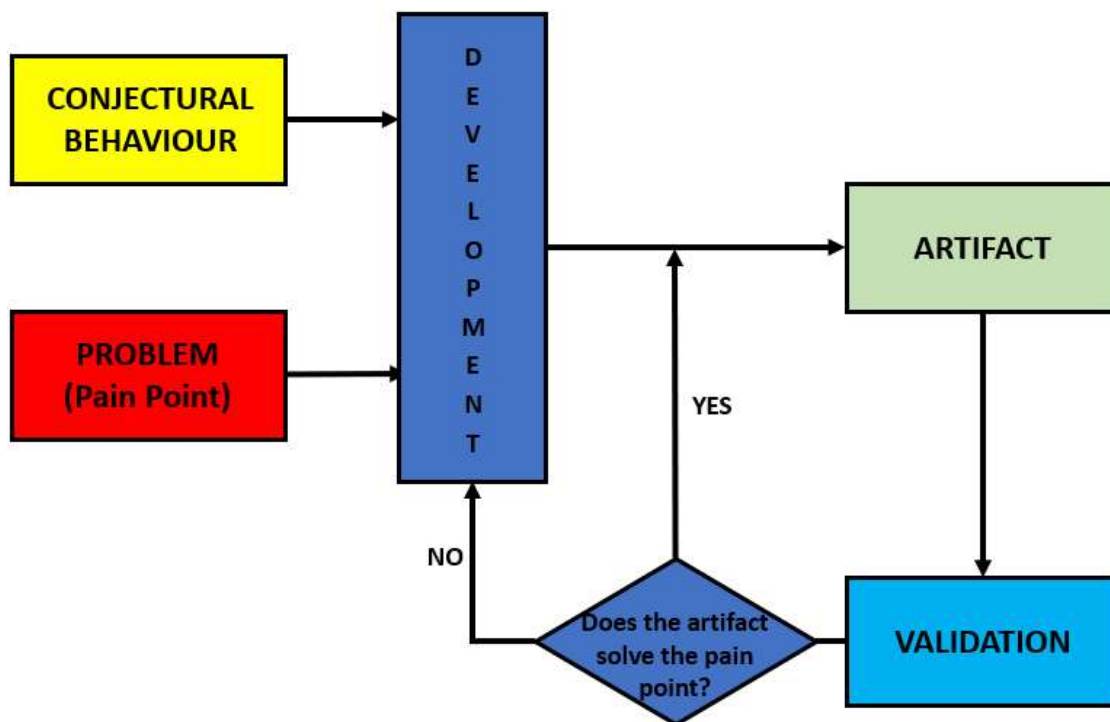
2. METHODOLOGY

The Methodology used is based on the Design Science Research Model (DSRM), which is a variation of the Design Science Research (DSR), as a mean 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 in order 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, communicate. This conjectural behavior is then applied on the development of such artifact, which is meant to solve an existing pain point that may bother those people [9].

DSR is largely used in the information systems (IS) field, leading to either a 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.

Figure 1. DSRM



Source: Adapted from [9]

2.1. 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 in order 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>).

The search resulted in only eleven papers, what 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 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 previous 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, what allowed the author to get more information about state-of-the-art technologies applied to surveillance systems.

3. RESULTS AND DISCUSSION

3.1. Conjectural behavior

Human aggression may be interpreted following either an evolutionary or a psychology approach, and comprehended because of natural selection, or 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 in the opposite way 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 in three categories: visual (facial expression, body language); auditive (linguistic speech, paralinguistic speech); and physiological (skin temperature, respiratory rate, brain activity; heart rate) [16].

3.2. 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 in two portions, being: hardware and software.

3.2.1. Hardware (sensors)

Thermal cameras are more appropriate to monitor violent movements once they are not dependent of 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.

3.2.2. 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 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 in 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 identification of the occupants. Unfortunately, this deteriorates the capacity of the software to detect emotions or other important information. To overcome this issue, techniques of generating facial anonymization have been proposed [19].

4. CONCLUSION

Aggressiveness is somehow present in the 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 cannot be avoided, it is desirable to collect and provide evidence of a crime.

Besides violence detections in terms of the safety of the passengers, it's important to think about a surveillance system also aimed to 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 on board of 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.

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