Study of Vulnerabilities in Designing and Using Automated Vehicles based on SWOT method for Chevrolet Camaro

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Abstract. Travel sickness of the passenger, lack of human control over driving, high level of complexity in construction and programming, possibility of technical failure, limited or no driving engagement are just some of the possible vulnerabilities when using an automated or an autonomous vehicle. There are also important benefits and clear advantages such as more time for relaxing, resting, sleeping, reading, or working during the travel. Therefore is a ”must”, to study the process of designing and using automated vehicles in order to outline vulnerabilities which may provide the mitigating solutions. As majority of the studies regarding vulnerabilities of the automated vehicles consist in fundamental research investigations a SWOT analyse of vulnerabilities in designing and using autonomous cars is thus necessary. The present work investigates methodological and designing aspects for researching the vulnerabilities in the process of developing and implementing automated driving, based on SWOT approach, simulation tools, practical measurement, experimental testing, sampling, graphical modelling, programming, and ethical considerations. Moreover, some aspects of the SWOT method led by multiple engineering and ethical problems are brought up and highlighted. Part of the data from conducted research concerning the designing and using autonomous vehicles made in a dynamic-based driving environment and with a real car are also applicable in sustaining the arguments.

1. Introduction

Individual vehicles and driverless taxicabs are nowadays the most important and necessary transport means due to rapid contagion in pandemic period. Designing and using automated vehicles is now an absolute necessity because of the high risk of sickness transfer from human to human (during pandemic). Having such cars with automated driving capacities may contribute to the containment of the spread and help the authorities. Also, smart driver-less automated cars may support vulnerable individuals to seek and obtain help from others. Nonetheless these autonomous vehicles may generate a multitude of vulnerabilities both in designing and during exploitation in road transport and traffic. Designing an automated vehicle is not an easy task due to the repeated programming and testing sessions in order to create a proper and adequate artificial intelligence to control the commands and cars’ behavior [1][2][3].

Using automated vehicles is entirely another problem based on the experience already acquired. All the operational commands on the actuators resulting in smooth and safe driving of the vehicle are based upon intelligent control of the car’s powertrain [4] and driving systems (steering and braking) during the transportation process. Developing learning-based programs in automotive engineering is a niche effort [5] which may lead to multiple discoveries and benefits such as fuel economy and carbon footprint reduction [6]. There are foreseen both advantages and disadvantages, benefits, and treats in automation of driving and road transportation processes based on future developments [7]. Travel sickness and lack of human individual control over the personal road traffic experience are few of the concern signals [8]. Interaction of human to vehicle essential information is also vital [9]. Electronic control [10] of the powertrain in coordination with the over-all vehicle management [11] system should provide [12] the user and the service staff with essential data properly displayed and grouped in order to minimize harshness and to increase the safety, pleasure and comfort of travel experience and cars' maintenance.

Investigating vulnerabilities and SWOT (strength, weaknesses, opportunities, and treat) aspects in designing and using automated vehicles takes into consideration the multiple and complex interactions between different life stages of the automotive product, especially when it comes to road traffic impact.

Figure 1 presents the virtual reality environment design in Unity 5 modelled in order to facilitate the simulation of automated car control and artificial intelligence applied to driving and to machine learning process or artificial intelligence (AI) in order to prevent transport and road traffic events [1],[2],[3],[4].

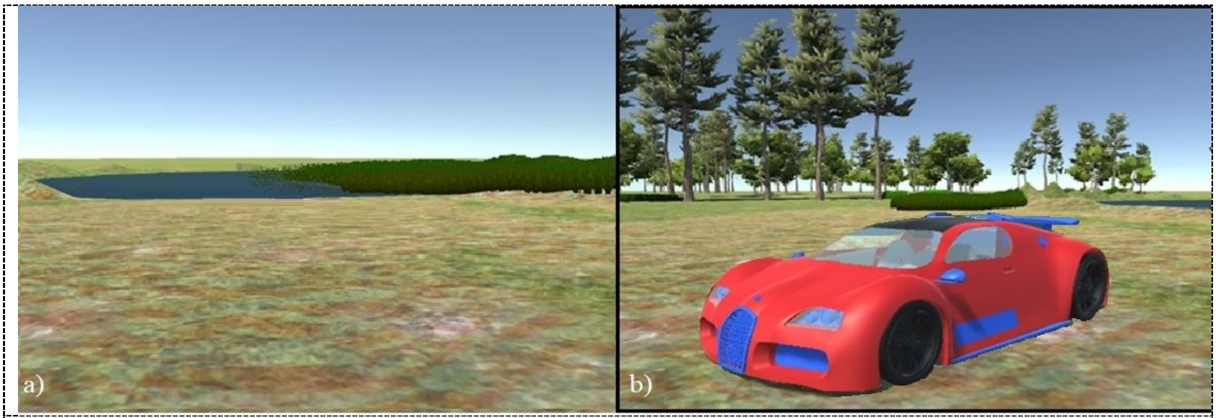


Figure 1. Virtual reality environment (a) and virtual automated car (b) designed in Unity [1],[2],[3].

Figure 2 shows the relations facilitated by the development of robotic automated vehicles with significant impact on road traffic, society, and transportation, implementing artificial intelligence (neural networks and machine learning), automation, robotics, and programming [3-5]. Mathematical modelling and computer science represent the fundamentals for robotics and automated systems (a). An input set of parameters shown in figure 2 (b) are processed and filtered through kernel component in order to generate an output value. There are also two hidden layers that control the output value. The neural networks are based on mathematical calculus at first layer, then a non-linear operation function in order to obtain features, followed by a pooling function which replaces the output value with a statistical processed result [1-5]. Artificial intelligence (AI) may be programmed using Bayes theorem.

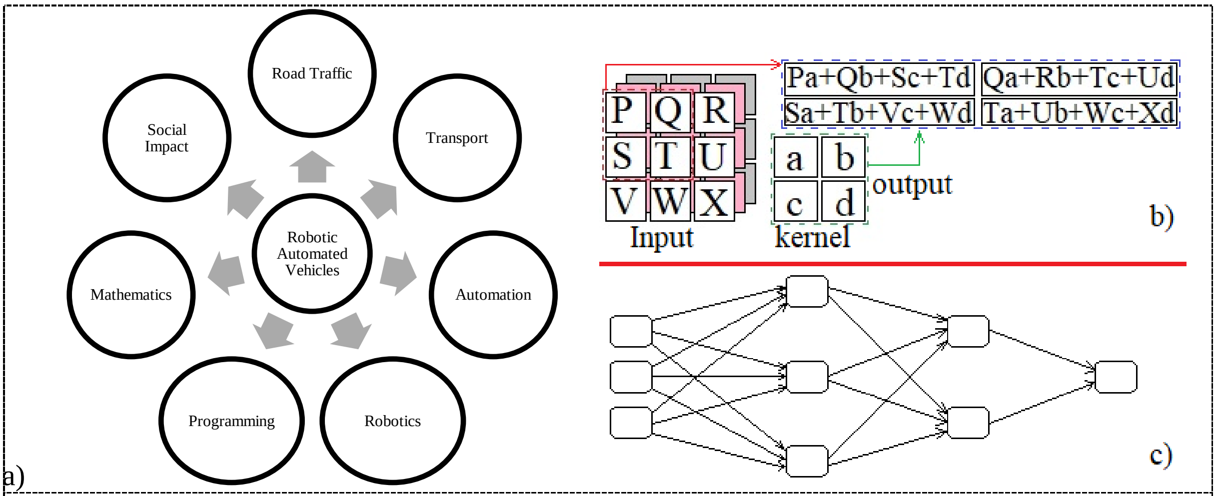


Figure 2. Relations of automated vehicles (a), machine learning (b) and AI neural networks [5]

2. Applied SWOT study and modelling

The applied study of vulnerabilities in designing and using automated vehicles is based on a predefined representation of strengths, weaknesses, opportunities, and treats (SWOT), aspects shown in table 1. In order to address these aspects controlled applied research is necessary. Considering this assumption, may be recorded that little research has been developed around the topic.

Table 1. SWOT descriptive data

Strengths	Weaknesses	Opportunities	Threats
Uniformity of experience	Complexity of protocols	More leisure time	Machine failure
Selfless driver	Lack of empathy	Less road crimes	System hackings
Permanent memory	Digital storage	Rapid data sharing	Data stealing
Remote control	Easy interception	Efficient use	Stealing from distance
High level control	Software failure	More programming	Cyber crimes
Internet connection	Privacy risks	Accessing more info	Personal data leaks
Programmed dynamics	Blind spots	Drive Standardizing	Travel sickness

Considering SWOT method for highlighting the aspects concerning the automated vehicles has been followed a designing of a robotic automated vehicle based on Chevrolet Camaro model which was replicated and tested in Virtual Reality application Unity 5 and afterwards validated with a series car (most similar and closely related to the digital version).

Most important technical data that must be studied in the present case are mechanical, electrical and digital in substance, due to the influence of kinematics (displacement, speed/velocity, acceleration), dynamics (force and torque), electric currents, voltages, and programming on the vehicle movement, travel experience and transportation safety.

Figure 3 highlights the connections and interactions between the shaping factors of the research, testing, and development regarding automated vehicles. This paper shows a study of vulnerabilities and basic considerations regarding materials and methods applied in designing and using Chevrolet Camaro automated vehicles. It will sustain and contribute other applied engineers to choose proper methods, measurements, design features, dynamics, and even ethical rules to be implemented and embedded in automated vehicles which will travel on roads in the future.

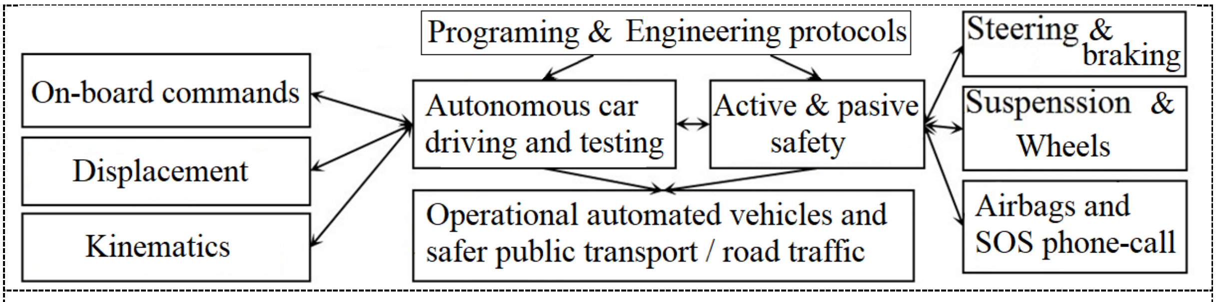


Figure 3. Interactions between factors which may shape automated vehicles future design and use

Programing AI with Bayes theorem where first probability is defined using a training set as shown [5]:

$$P(z|w) = \frac{P(w|z)P(z)}{P(w)} = \frac{P(z)\prod_{i=1}^{N} P(w_i|z)}{P(w)} \quad (1)$$

where P(z) is the prior / first probability; P(w) - last prob.; P(w|z) – class conditioned probability.

Chevrolet Camaro has been developed in six generations since 1967 till present days of which latest models are suitable for automation. The important technical specifications are given in table 2 [13],[14].

Table 2. Specific data for the Chevrolet Camaro vehicle under the applied study [13]

Parameter	Chevrolet Camaro
Car engine	3.6 L V6 335 HP 250 kW
Fuel system	Gasoline
Gear Box	8L45-automatic
Traction/Steering	Rear drive / Front steering
Tires	245/45R20 (front) 275/35R20 (rear)

In figures 4 to 12 are shown the significant steps in designing and using an automated Chevrolet car.

Figure 4. Using Car Engine Script for data set-up.

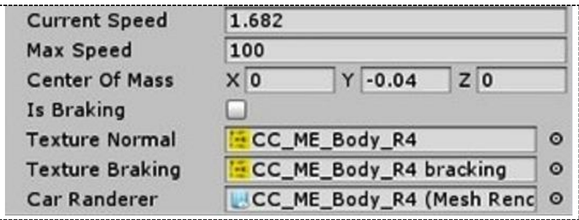


Figure 5. Input the data regarding dynamics.

Figure 6. Real Chevrolet Camaro under the study.

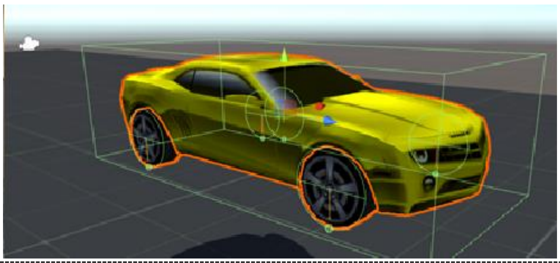
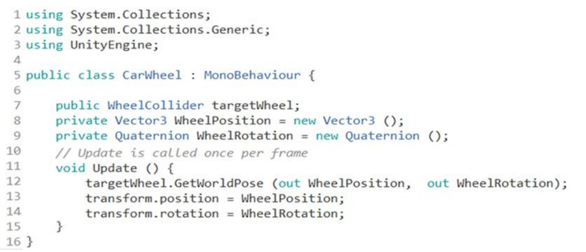


Figure 7. Virtual modelled Chevrolet Camaro.



```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

public class CarWheel : MonoBehaviour {

    public WheelCollider targetWheel;
    private Vector3 WheelPosition = new Vector3 ();
    private Quaternion WheelRotation = new Quaternion ();
    // Update is called once per frame
    void Update () {
        targetWheel.GetWorldPose (out WheelPosition,  out WheelRotation);
        transform.position = WheelPosition;
        transform.rotation = WheelRotation;
    }
}
```

Figure 8. Programming the wheel collider in VR.

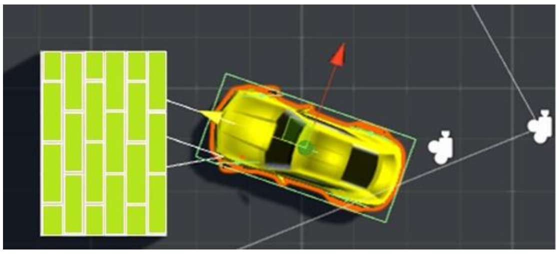


Figure 9. Learning how to avoid the obstacles.

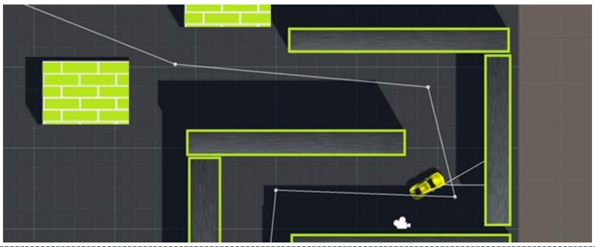


Figure 10. Solving the Maze problem with VR.

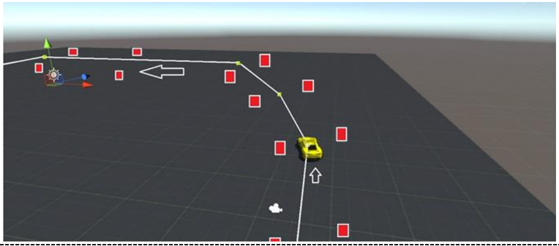


Figure 11. Travel on a specified track in VR.

3. Observations and conclusions

Autonomous or automated cars may contribute to enhance the benefits of the users due to the free time equally available for all the vehicle's occupants to be spent as they see fit in multiple leisure and non-driving tasks. Anyway, this fact leads to some treats and vulnerabilities, such as motion sickness and total lack of control.

The most significant vulnerabilities which were uncovered during the present study are situated both in design phase and in using of the real Chevrolet Camaro vehicle with automated system. For the first step of the study for implementing the automated driven vehicle in virtual environment the weaknesses or vulnerabilities are consisting in the fact that only few of the operational parameters may be replicated and applied at the present stage of the development. The analysed parameters cover mostly kinematic and dynamics of the vehicle and powertrain. Other vulnerabilities are found in the complex machine learning of AI, which is a limited step by step process and has possible negative impacts during travel. The practical testing has although much more vulnerabilities because there is no self-driving vehicle now. Thus, in practical research, now is only possible to drive Chevrolet Camaro with driver assistance.

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