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Designing an Artificial Intelligence Control Program Model to be Tested and Implemented in Virtual Reality for Automated Chevrolet Camaro †

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† Presented at the 14th International Conference on Interdisciplinarity in Engineering—INTER-ENG 2020, Târgu Mureș, Romania, 8–9 October 2020.

Published: 22 December 2020

Abstract: A control program was designed with Unity 5 virtual reality application in the automotive and robotics field. Thus, a virtual model of a robotic car was tested in a virtual reality program. After optimization, the smart controller was implemented on a specific model of the automated Chevrolet Camaro. The main objective of the present paper is to design a control program model to be tested in virtual reality and in a real-size car. Results concerning the virtual modeling of an automated car and its artificial intelligence controls have been presented and discussed, outlining the forces, torques, and context awareness capabilities of the car.

Keywords: artificial intelligence; automated car; automotive; robotic vehicle; virtual reality

1. Introduction

Design and research are some of the most important sequences in the production protocol [1,2]. Defining the shapes, instruments, and methods used for production and optimization is inherent for design sequences [3]. The purpose of this paper is to outline the design sequences and manufacturing of an operational model. Additionally, it features the capability of automated driving, being controlled by a digital written program. It was first tested in virtual reality. Preparing the model for further development makes the progress in the automotive and robotic sector susceptible for convergence and accelerated unification. Communication technologies and mobile virtual fence systems are contributing to the topological object recognition process [4,5].

Automation and robotics are applied more and more in many industries, including automotive technology [6]. Robotization of transmission and gear shift mechatronics are popular applications [7]. Converging the automotive industry and robotics with complex mechatronics systems will provide the possibility for autonomous or automated driving in the near future [8]. The current problem is the integration and optimization of all the given systems and interdisciplinary efforts for one direction effort, which is road traffic safety [9]. Mechatronic systems should be precisely programmed like automated robots to perform safely in complex traffic scenarios [10]. Artificial intelligence may be implemented in electric cars to improve performance and responses [11–14]. Standards and measures are provided by different entities regarding self-driving cars to solve safety problems and to optimize road traffic flows [9,15–18]. An optimized model of a control program was designed, tested, and implemented in virtual reality for an automated robotic car. Specific targeted objectives were the following: define the technical data concerning the robotic vehicle; use the support of driver-assistance system capabilities in a real-size model; create a virtual environment to match the challenges from real-world driving situations; program an automated model of the Chevrolet Camaro to follow different tracks in predefined scenarios; use different technologies (such as a mobile virtual fence and a context awareness mechanism) to improve communications of the automated vehicle with the traffic and infrastructure; configure the car control script in Unity 5 application; define the car dynamic parameters (forces and torque) and kinematic; and prepare the experimental testing of the real-size car. It was an important achievement to complete the model and test it in Unity 5 (as an artificial intelligence application) for validating the first step of research. It also used mobile virtual fence technology and vehicular network capabilities to increase safety and communication. Graphic design and programming were provided. The second step consisted of transferring the know-how to a real-size model car. In this case, the dynamics and detail aspects were more complex. Smart robot cars bring benefits and opportunities, but, at the same time, vulnerabilities and threats. More investigations should be made regarding automated cars in road traffic conditions.

2. Materials and Methods

The research methodology was based on simulation and testing, first in virtual reality and secondly, step by step, in a practical set up on a real-size model to highlight all the problems and limits of the automated driving process. Unity 5 digital application was used to generate shapes and simulate the robotic vehicle behavior. Multiple driving scenarios were studied to acquire the most significant actual values regarding the kinematics and dynamics of the simulated vehicle in virtual and real scenarios.

Materials used for the research were the Unity 5 program and Chevrolet Camaro model, for testing and investigating automated driver capabilities, with technical data given in Table 1. These requirements were matched in the experimental testing of the automated vehicle.

Table 1. Technical data regarding the robotic vehicle materials used for research.

Basic System	Value 1	Value 2
Propulsion	V6 engine	335 HP
Wheels	245/45R20 (front axle)	275/35R20 (rear axle)
Transmission	automatic	8L45 [1]

[1] Supporting driver-assistance system capabilities.

Virtual reality environment, known as Unity 5, allows the implementation of a program based on artificial intelligence in order to control the vehicle model, both in start-stop procedures and on the track following and collision avoidance, with a simplified schematic of the complex connections, shown in Figure 1.

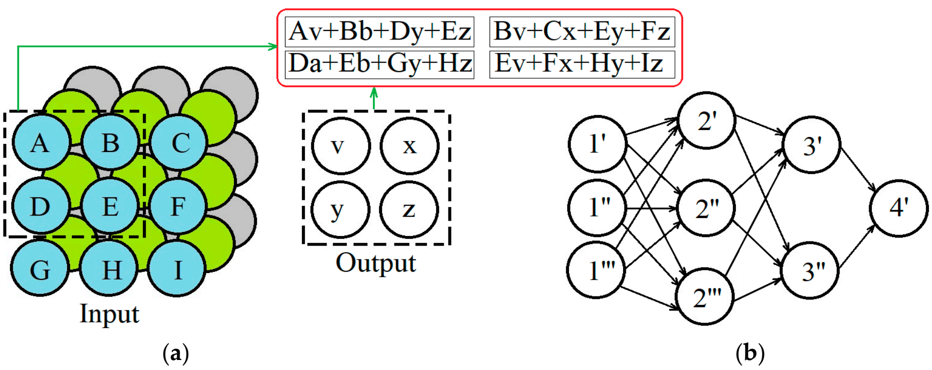


Figure 1. Simplified design of controlling methodology for the artificial intelligence (AI) program with neural networks: (**a**) applied method for machine learning; (**b**) artificial intelligence neural network combinations [1].

3. Investigation and Results

Results obtained by the virtual modeling in the Unity 5 simulation environment were compared with real-time testing data. The main findings of the robotic engineering research show that there were some kinematic limits for the designed vehicle model. Thus, the optimal safety was obtained for an alternative curving track at velocities under the value of 35 km/h. Sinusoidal driving of the tested vehicle with the value above was susceptible to safety hazards.

3.1. List of Smart Robotic Automotive Applications and a Technological Investigation

3.1.1. Smart Car versus Robotic Vehicle

The list of distinctive classes of smart vehicle applications:

- Genuine smart features on-board implemented by manufacturer
- Old vehicle with up-graded smart technologies
- Context-aware computing inside car
- Mobile virtual fences
- Mutual awareness mechanism
- Research or prototype smart cars

The list of automated or robotic car prototypes may be structured as follows:

1. Apple self-driving vehicles
2. Connected car with autopilot
3. Tesla autopilot
4. Volvo's autonomous concept vehicle
5. Waymo self-driving autonomous cars

3.1.2. Investigating the Integration of Innovative Technologies

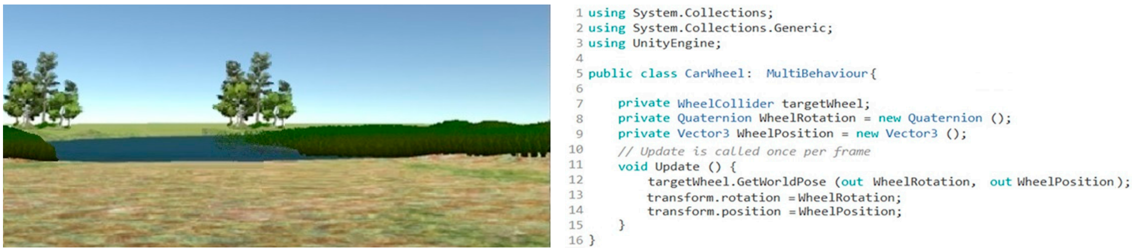
It is considered appropriate and factual to investigate the integration of new features and technologies to address conventional problems and risks, such as road events and traffic accidents. Virtual fence technology supports the inter-connection of mobile robots to enhance the mutual awareness factor. Vehicle-to-vehicle, vehicle-to-infrastructure, and vehicle-to-everything types of communication were considered and used to facilitate and implement the connected car feature in robotic vehicle development. Car-to-car connectivity facilitates implementation of the mutual awareness mechanisms.

3.2. Virtual Reality Modelling and Design Results

Virtual reality program Unity 5 was used for environment generation and other testing components assembling, as shown in Figure 2. Results obtained in the designing process of the artificial intelligence control program consisted of digital content used for environment and track creation in virtual reality (VR), as well as the automated robotic Chevrolet Camaro vehicle, implemented in Unity 5 for drive testing.

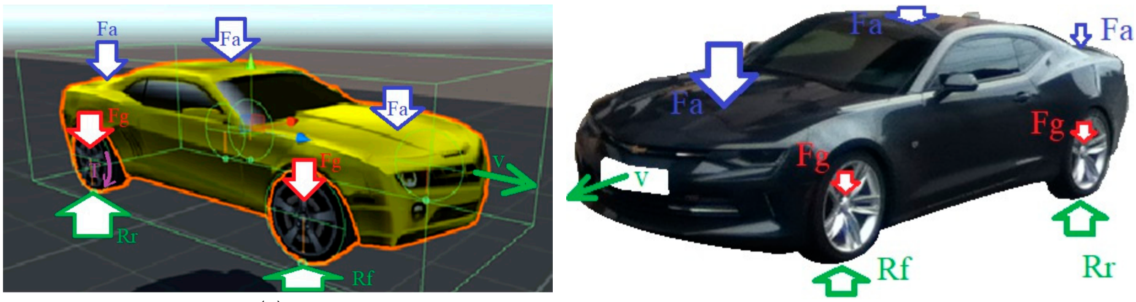
Virtual robotic car Chevrolet Camaro in Unity 5 had automated driving features, and the real car supported the validation of the concept, with a driver assistance system, as shown in Figure 3. Air force (Fa), force of gravity (Fg), road reactions (Rf, Rr), and velocity were the main kinematic and dynamic parameters considered in the digital program, besides the engine's torque and power output.

Mobile virtual fence (MVF) was used by the automated robotic car, Chevrolet Camaro, in the Unity 5 testing scenario when self-driving to support the safety program and accident avoidance, as shown in Figure 4. Wireless communication capability and MVF make vehicular networking a possibility.



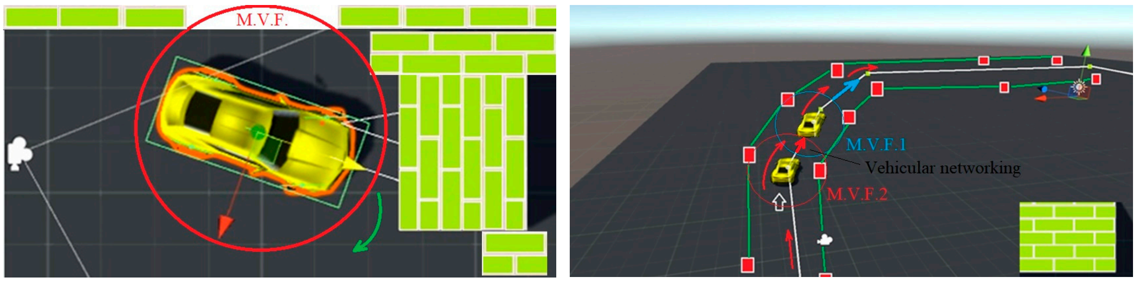
(**a**) (**b**)

Figure 2. Basic programming results in virtual reality program Unity 5: (**a**) Environment used for track generation for digital testing of the robotic car; (**b**) sequence of the program used for automation of the Chevrolet Camaro robotic model.



(**a**) (**b**)

Figure 3. Virtual reality Chevrolet Camaro model in Unity 5: (**a**) Digital model of tested robotic car; (**b**) actual Chevrolet Camaro model with the driver assistance program used for road testing conditions.



(**a**) (**b**)

Figure 4. Robotic Chevrolet Camaro model supported by mobile virtual fence (MVF) in the Unity 5 virtual reality drive test: (**a**) Digital model of tested robotic vehicle is self-driving away from an obstacle; (**b**) vehicular mobile networking when both cars communicate and interact through their MVFs.

The design of the car engine and the vehicle system output performance was made in a virtual reality program, known as Unity 5, by using a script and dialog boxes for input data, as shown in Figure 5. Results are supported by an artificial intelligence control program, which used vehicle-to-infrastructure and context-aware technologies. An automated robotic Chevrolet Camaro, implemented and tested in Unity 5 for situation-aware capability and obstacle avoidance maneuvers, was designed for the task.

The context awareness mechanism, with the mobile virtual fence system, allowed the virtual reality program to adjust the maneuvers for avoiding the obstacles and to reconfigure the trajectory through artificial intelligence, as shown in Figure 6. The virtual automated car, Chevrolet Camaro, had AI program features in Unity 5 to use a speed-reactive mobile virtual fence system with physical object-aware computing and accident-avoidance capacity.

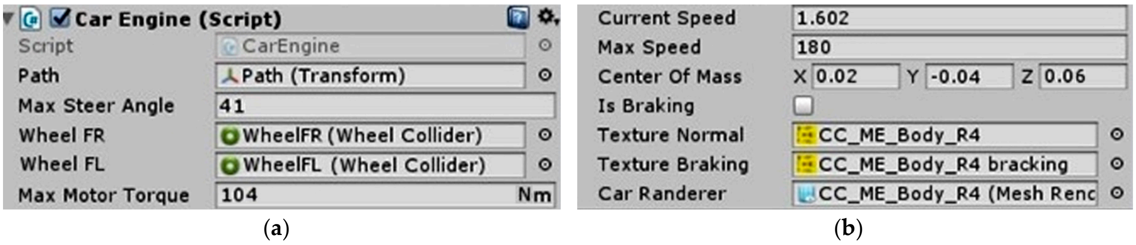


Figure 5. Basic digital support in configuring the car control program script in Unity 5 application: (**a**) Car engine script used to define maximum motor torque; (**b**) kinematic parameter definition.

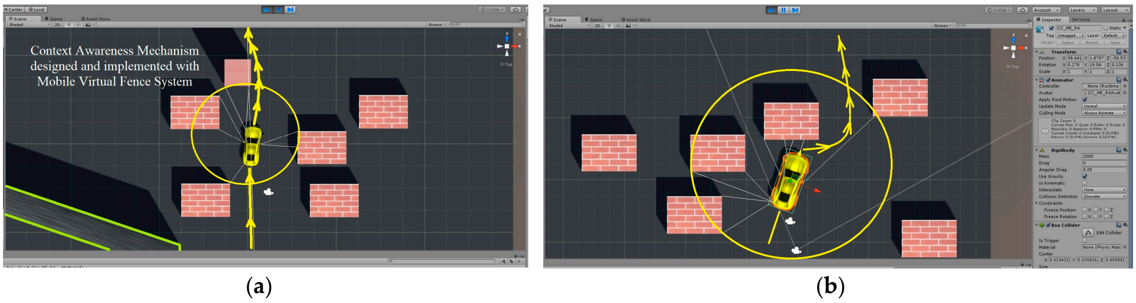


Figure 6. Artificial intelligence control program of the robotic vehicle model in Unity 5 virtual reality: (**a**) Context aware computing applied to self-driving optimization for avoiding a few physical objects; (**b**) vehicle-about-everything type of sensing for object avoidance program and track re-defining.

Application of the mobile virtual fence technology (MVFT), both in Unity 5 and the driver assistance system used by the Chevrolet Camaro vehicle, was useful for performance optimization, as shown in Figure 7. Any physical object could trigger the proximity detection sensors and context-aware system. A real-road scenario allowed the detection of physical objects and mutual awareness in vehicular networks through wireless communication technologies. The auto-driving was made by cruise-control.

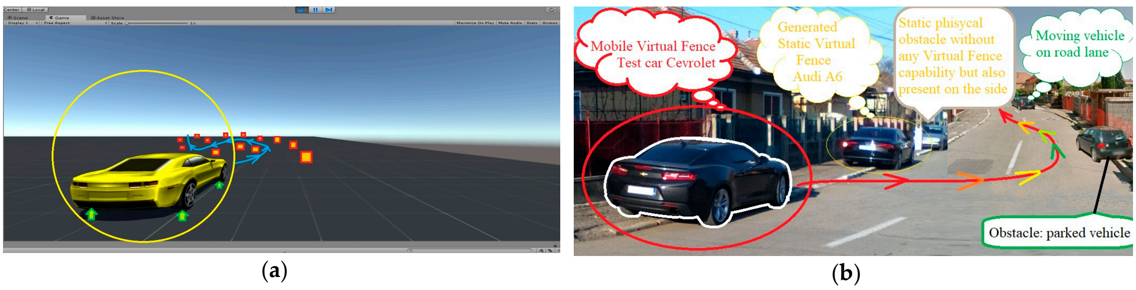
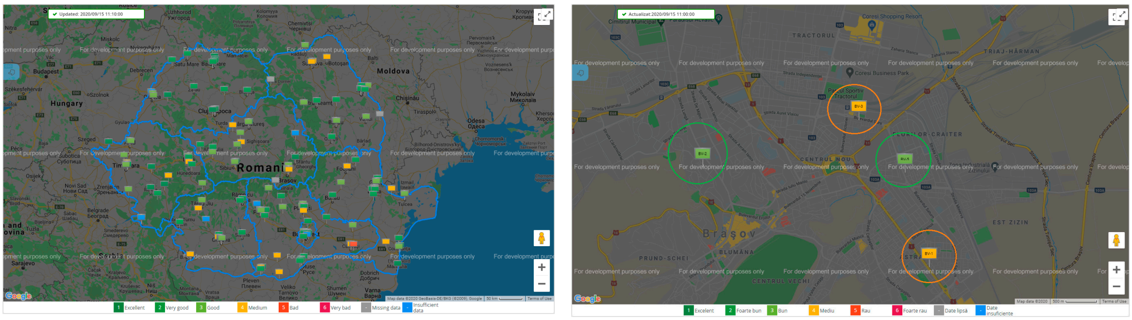


Figure 7. The Chevrolet Camaro was equipped with MVF both in the digital and actual drive test environment: (**a**) Robotic virtual modeled vehicle using the self-driving optimization capacity to avoid objects; (**b**) driver assistance system was applied to validate the virtual distilled model of the robotic car.

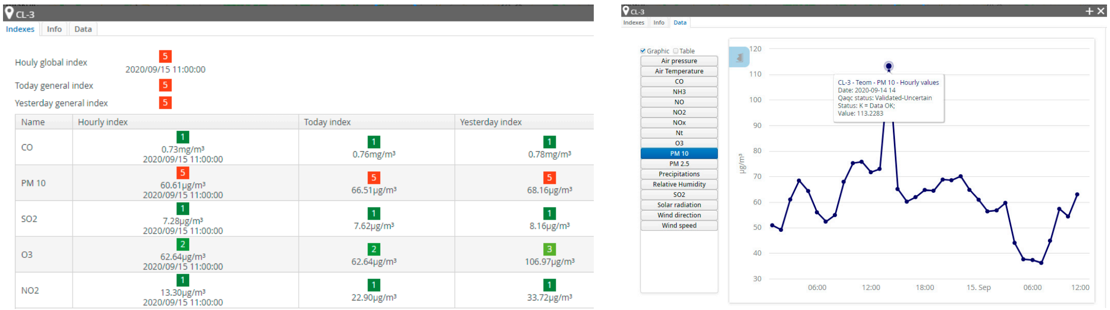
Using the mobile virtual fence technology (MVFT) and Wi-Fi connectivity with a smart vehicle, in addition to previously presented data, the research scenario was completed with accessibility to environmental data for road route optimization [15], as shown in Figure 8. The vehicle is connected to the infrastructure and reads the pollution map, thus reconfiguring the street route to follow.

Through available connectivity, the smart device accessed the data concerning the red spots of the pollution level and highlighted the peaks, as shown in Figure 9.



(**a**) (**b**)

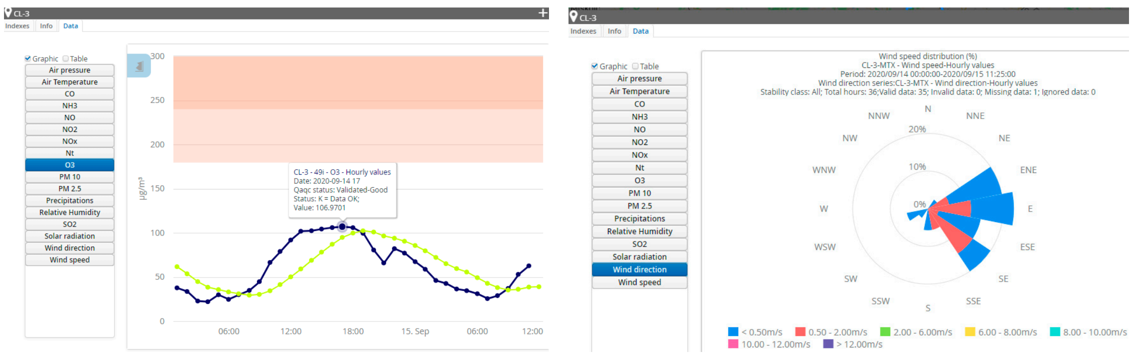
Figure 8. Environmental checking maps when configuring the route scenarios to be followed by car: (**a**) Overall map of the entire country showing the monitoring stations placed in different points for air quality measurement; (**b**) close view of the city map with environment checkpoints for pollution.



(**a**) (**b**)

Figure 9. The environmental data accessed a Wi-Fi connection and was made available on the local area network: (**a**) Accessing the synoptic view of the pollutants panel from a red spot to determine the value; (**b**) graphical representation of the hourly evolution and the peak value for the spotted pollutant.

Tropospheric ozone (O3) actual values and its peak point, as well as wind direction data, were also accessed from a virtual cloud to perform better optimization of the road route in traffic, actual values being numerically available and graphically represented, as shown in Figure 10.



(**a**) (**b**)

Figure 10. Cloud data regarding the environmental check for tropospheric ozone (O_3) and windy conditions in road route configuration: (**a**) Ozone (O_3) level variation and its peak value, accessed from a virtual cloud; (**b**) wind direction and speed distribution for a 36 h total interval.

The artificial intelligence program model was designed to test and implement both the virtual reality and actual vehicle, Chevrolet Camaro, as shown in Table 2. Wireless networks and hot spot function allowed the creation of a mobile digital sphere. The latter could be assimilated to the more popular mobile virtual fence (MVF), which was considered as the basis of vehicular networking.

Context-aware mechanisms consist of sensors and an electronic control unit that processes signals from all sides of the vehicle to properly command the steering and powertrain. Investigation and analyze of strengths, weaknesses, opportunities, and threats outlines some of the most interesting results and vulnerabilities, as presented and centralized in Table 2.

Table 2. Results of strength, weakness, opportunity, and threat (SWOT) investigation.

1 Strength	2 Weakness	3 Opportunity	4 Threat
Stored knowledge	Complexity	More creativity	Digital blockage
Self-driving	Limited sensing	Context aware study	Inadequate response
Internet of things	Easy interception	Connected car service [1]	Lack of privacy

[1] All the revisions and vehicle failures are digitally planned and followed precisely by maintenance staff.

3.3. Programming Artificial Intelligence with Bayes Theorems

The primary probability used by the AI was defined using a group for training, as follows:

$$A_I(c|d) = [A_I(d|c) \cdot A_I(c)]/A_I(d) = [A_I(c) \cdot \Pi^N{}_{i-1} \cdot A_I(d_i|c)]/A_I(d), \quad (1)$$

where $A_I(c)$ is the prime probability; $A_I(d)$ is the post probability; and $A_I(d|c)$ is the training group probability.

4. Discussion and Comparative Relation with Other Contributions in the Field

Specific contributions in the process of designing and manufacturing of a control model program, destined to be implemented in an automated car, consisted of defining the track to be followed by the robotic vehicle during virtual reality testing. Specification of the vehicle model chosen for simulation and real-time testing contributed to the innovative character of the study. Thus, original aspects of the developed research comprised a modern Chevrolet Camaro (a virtual model) adapted to autonomous driving on a defined track and real-time testing with an adapted similar vehicle model.

Manufacturing of physical systems and complex virtual environments corelates quite intimately with the recent published works in the field [1–5]. Production of those elements and connections between components allowed complete programing of a robotic vehicle to operate in alternate dynamic and kinematic regimes, including the usage of the data, not only the display of some information [6]. Using virtual reality in the manufacturing/development process of the specific operating environment for the robotic vehicle is a complex task, which places the present study in a symbiotic relation with the rest of the research [8–12]. With the VR program, three important scenarios for applying AI in a robotic car should be considered as the following: 1. environmental inspection automated vehicle, 2. as a taxi, and 3. as an ambulance. In the present paper, the first scenario was considered.

In addition, the authors developed some advanced algorithms/applications for improving the road route optimization by considering multiple factors (physical and chemical, some of them accessed from the cloud, other determined directly). The first part of the study was supported by some features of a software application, but the second phase was originally proposed and developed in a cross-reference participatory act with the road traffic and environmental management discipline.

5. Conclusions

Designing, testing, and implementation of a control program in VR for automated driving of robotic Chevrolet Camaro was successful and allowed us to gain insight in the problems that are necessary to be considered in further investigations, both in simulations and practical tests. The applied testing in real-size conditions on the actual road is still a problem because there is not any completely developed robotic car yet. The existing driver assistance systems are optimal for the partial kinematic control of the car, but still do not allow full dynamic programming.

The most important aspects covered in the present paper were designing the phase and implementation of a control program for the Chevrolet Camaro passenger car with automated driver assistance in VR and on the actual road. The first step of investigation was the simulation program and the second phase actually tested driver assistance and MVF on the road.

Author Contributions: Conceptualization, D.-L.B. and A.-I.B.; methodology, D.-L.B.; software, D.-L.B.; validation, L.A., D.-L.B., and A.-I.B.; formal analysis, A.-I.B.; investigation, D.-L.B.; resources, A.-I.B.; data curation, D.-L.B.; writing—original draft preparation, A.-I.B.; writing—review and editing, D.-L.B.; visualization, A.-I.B.; supervision, A.-I.B.; project administration, D.-L.B.; funding acquisition, L.A. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Acknowledgments: Technical support was given by Florin Covaciu from Robotics Department and by Iustinian Berindei from Advanced Techniques in the Automotive Engineering; Faculty of Automotive Engineering, Mechatronics and Mechanics; Technical University of Cluj-N.; Romania.

Conflicts of Interest: The authors declare no conflict of interest.

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