Conflict Detection in Automated Vehicle Testing Through Gamification

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Abstract

The **validation and testing** of automated vehicles (AVs) present **significant challenges**, particularly due to the **impracticality of extensive real-world driving tests**. While virtual testing and simulation offer an alternative, they often miss real-world complexity.

To address this, a **serious game** called Automated Vehicle Validation (AVVA) was developed as a gamified platform that engages players to generate diverse, realistic driving scenarios.

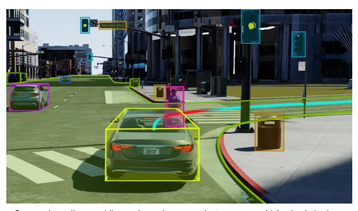
Motivation

From a distance-based validation to a scenario-based validation approach

Distance-based Validation

Source: https://www.autonomousvehicleinternational.com/news/robotaxis/waymo-expands-driverless-robotaxi-testing-to-phoenix-freeways.html

Scenario-based Validation



Source: https://www.nvidia.com/en-us/use-cases/autonomous-vehicle-simulation/

- Operating in the field
- Time consuming and costly
- Can be safety critical
- Random test case sampling

→We need to drive a lot of kilometers/miles. [1]

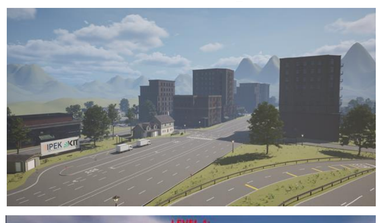
- Virtual testing will be mandatory in the release process of future vehicles
- Virtual testing must be executed on large scale

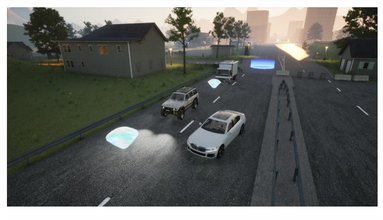
Scope

Leveraging gamification to generate a wide range of realistic driving scenarios for comprehensive automated vehicle testing

- Development a **gamified environment**
- Design **levels and minigames** for scenario generation
- Support for simultaneous **multi-user gameplay**
- Record relevant scenarios
- **Detect and record the critical and edge cases**
- Easy re-evaluation in a **high-fidelity environment**

Development of a Serious Game





Foundation

- Built on **Unreal Engine 5** [2]
- Model based on a real environment**: ZalaZONE** automotive proving ground [3]

Features

- **Multi-Player**
- Different **roles** (e.g. cars, construction site vehicles, VRU, etc.)
- **Freeroam** game mode
- **Mini-game and level mode**: challenges or basic scenarios
- The players have to solve the challenges alone or cooperatively

Use Case Conflict Detection and Resolution

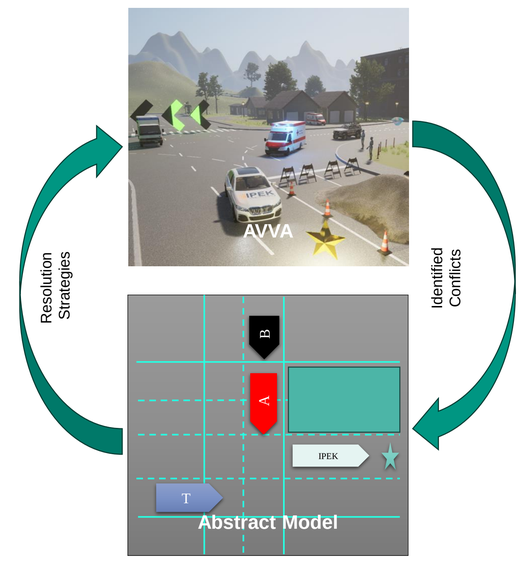
Conflict Situations

- Apart from critical scenarios autonomous traffic agents (ATAs) are **faced with conflict situations in the real world**
  - A **conflict** is a situation where an ATA cannot choose any action without violating rules or (safety) goals [4]
- In the informatics department **conflict detection and resolution** is an ongoing research topic but there is **lacking data for conflict research**

Proposed idea: **Use the AVVA videogame** not only for scenario, but also for **conflict generation**!

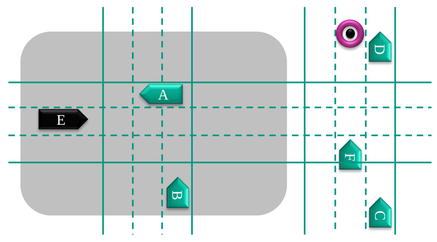
Proposed Workflow

1. Players interact in AVVA and **create conflict situations as a byproduct**
2. Conflicts are being transferred to an **abstract representation**
3. The abstracted conflicts can be **clustered** and **optimal resolution strategies** can be developed or selected
4. The resolution strategy will then be **applied** in AVVA



Urban Multi-lane Spatial Logic (UMLSL)

- For the abstract representation of conflicts, the Urban **Multi-lane Spatial Logic (UMLSL)** [5] has been introduced
  - Description of traffic scenarios based on the car's view
  - Evolution of scenarios over time
- UMLSL is used to **formalize what actions are safe and legal**
- If no available action is safe and legal
  → **Conflict**



$$re(E) \frown \begin{matrix} re(A) \wedge cs \\ free \wedge cs \end{matrix}$$

Outlook

Toolchain Completion

- **Automate detection** and storage of critical scenarios in **OSI** format.
- Facilitating **re-evaluation in high fidelity simulation environment**

Conflict Resolution Strategy Enhancement

- **Refine conflict resolution strategies**
- Enable algorithms to handle more realistic and complex environments.

Expansion of AVVA Capabilities

- Expansion of AVVA into a **large-scale ecosystem**
- **Connect with other simulators** for enhanced integration and simulation capabilities

References

[1] Hermann Winner et al. Handbuch Fahrerassistenzsysteme. Wiesbaden: Springer Fachmedien Wiesbaden, 2015. ISBN: 978-3-658057336. DOI: 10 . 1007 / 978 -3-658-05734-3.
[2] Epic Games. Unreal Engine 5. Version 5.0. Accessed:2024-10-09.
[3] Tam´as Tettamanti et al. "Vehicle-In-the-Loop Test En-vironment for Autonomous Driving with MicroscopicTraffic Simulation". In: 2018 IEEE International Con-ference on Vehicular Electronics and Safety (ICVES).2018, pp. 1–6.
[4] Maike Schwammberger. "An abstract model for provingsafety of autonomous urban traffic". In: TheoreticalComputer Science 744 (2018).
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