**Vocabulary of Calibration Metrics for Co-Simulation of Traffic:**

The goal of this task is to develop a comprehensive vocabulary of calibration metrics for each simulation environment within the multi-simulation platform, initially focusing on integrating Virtual Reality (VR) and micro traffic simulators. This vocabulary will serve as a foundation for accurate calibration and synchronization of diverse simulation environments, with the capability to expand and accommodate additional simulations in the future.

The output of this research task will be a well-structured vocabulary of calibration metrics for each simulation environment, starting with VR and micro traffic simulators. This foundational work will establish the basis for precise calibration processes, ensuring that simulation outcomes closely align with real-world observations. Additionally, the developed framework will offer a flexible foundation for expanding the multi-simulation platform to include diverse simulation environments in subsequent phases.

**VR evaluation & calibration metrics:**

Immersion and presence in the VR world are critical elements for designing evaluation metrics.

Fidelity is not synonymous with performance; the training experience also significantly contributes to overall effectiveness [1]. The evaluation metrics show as Table 1.

|  |  |  |
| --- | --- | --- |
| Metric Category | Metric Name | Description |
| Digital Sensory System Fidelity | Visual System Fidelity | Frame Rate, Field of View (FOV), Field of Regard (FOR), Display Size & Resolution, 3D Graphics Quality |
| Auditory System Fidelity | Audio Resolution, Realism of Surrounding Audio, Quality of Audio Stimuli |
| Haptics System Fidelity | Haptic Movement Capability |
| Tracking System Fidelity | Body Movement Tracking | Key points of body movement tracking |
| Motion Tracking System Accuracy | Accuracy of tracking body movements |
| Synchronization of Tracking Data | Coordination between tracking data and rendering |
| Advanced Hardware and Software | Requirement for advanced hardware and software |
| Simulation System Fidelity | 3D Model Quality | Quality of 3D models used in the simulation |
| User Interface (UI) Design | Design and usability of the user interface |
| Integration of System Data | Integration of Additional Hardware | Integration of hardware such as racing wheels |

Table 1. The evaluation metrics of VR based system

To evaluate your VR system using these metrics, first identify and prioritize the key factors affecting fidelity. Conduct both objective and subjective evaluations to gather comprehensive data. Validate and consolidate the results to ensure reliability. The review suggests assigning scores to various factors and multiplying by an importance index to derive final scores, helping to quantify the evaluation and highlight areas for improvement.

**Microsimulation calibration metrics:**

Key SUMO calibration metrics include vehicle speed, traffic density, acceleration, deceleration, road conditions, and weather impacts. Studies by Krajzewicz et al. [2] and Treiber et al. [3] emphasize these metrics for realistic simulations. Additionally, driver behavior and compliance with traffic signals, discussed by Van Arem et al. [4], are crucial for accuracy. These metrics ensure SUMO simulations align with real-world conditions, enhancing their reliability and utility in traffic research.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Traffic Flow Dynamics | Vehicle Dynamics | Environmental Factors | Behavioral Factors | System Performance |
| Vehicle Speed | Acceleration | Road Surface Condition | Compliance with Traffic Signals | Simulation Speed |
| Traffic Density | Deceleration | Visibility | Gap Acceptance | Data Synchronization |
| Traffic Flow | Headway | Weather Conditions | N/A | N/A |
| Lane Change Frequency | N/A | N/A | N/A | N/A |

Table 2. SUMO calibration metrics

**Other Calibration Metrics:**

This report focuses on calibration metrics for VR and micro-simulation. However, other elements also need calibration. A multi-modal co-simulation platform must ensure robustness, low latency, and adaptive capability with hardware and operating systems. The primary goal remains the performance of the VR system and the micro-simulation system. Additionally, incorporating human factors will be crucial for system calibration.

**Reference**:

1. Al-Jundi, Hamza A., and Emad Y. Tanbour. "A framework for fidelity evaluation of immersive virtual reality systems." *Virtual Reality* 26.3 (2022): 1103-1122.
2. Krajzewicz, Daniel, et al. "Recent development and applications of SUMO-Simulation of Urban MObility." *International journal on advances in systems and measurements* 5.3&4 (2012).
3. Treiber, Martin, Ansgar Hennecke, and Dirk Helbing. "Congested traffic states in empirical observations and microscopic simulations." *Physical review E* 62.2 (2000): 1805.
4. Van Arem, Bart, Cornelie JG Van Driel, and Ruben Visser. "The impact of cooperative adaptive cruise control on traffic-flow characteristics." *IEEE Transactions on intelligent transportation systems* 7.4 (2006): 429-436.