Demo: CiThruS Traffic Scene Simulator

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***Abstract*— This paper describes the main features of our open-source CiThruS simulation environment and a demonstration setup for it. This lightweight simulator is designed for 360-degree traffic imaging at arbitrary positions in the city. It is built with Unity using the open Windridge City Asset, which we populated with autonomous vehicles and pedestrians. The vehicles navigate the city by following predetermined and user-customizable nodes on the map. They can also detect other vehicles, pedestrians, and traffic lights for simple collision avoidance and a smoother traffic flow. The pedestrians walk on the sidewalks and stop at the traffic lights when crossing streets. Weather, time-of-day, and lens effects bring the environment closer to the reality. In the demonstration, the simulation is controlled with an Xbox controller and run in real time on a consumer-grade laptop equipped with an Intel Core i7 4-core CPU and Nvidia GTX 1060 GPU.**

Keywords—Traffic simulator, open-source software, scene population, traffic imaging, Unity 3D engine

I. Introduction

Advanced driver-assistance systems (*ADAS*) [1], [2] are being developed to improve vehicle safety, driver behavior, and driving experience. Particularly, an increasing number of modern vehicles contain video-based ADAS to detect other vehicles, pedestrians, and surrounding obstacles. The next-generation systems are also able to leverage *vehicle-to-everything* (*V2X*) communication to provide vehicles with more visual data about their environment.

In vision-based ADAS development, the simulation environment is a must-have for testing different parameter settings and verifying the operation before actual implementation. However, the existing traffic imaging simulators are either expensive or lacking in usability or modifiability, especially when specific camera positioning and dynamic image distortions are of particular interest.

This paper presents the main features and a demonstration setup demo for our open-source *See-Through Sight* (*CiThruS*) simulation environment [3]. It is designed for lightweight 360-degree traffic imaging to facilitate the development of vision-based ADAS and associated V2X communication for next-generation vehicles. The real-time performance was achieved by simplifying the behavior of the vehicles and pedestrians, i.e., they behave realistically enough for traffic imaging but without any further intelligence. The simulator is available online at *github.com/ultravideo/CiThruS-simulation-environment*.

The rest of this paper is organized as follows. Section II introduces the features of the CiThruS simulation environment. Section III compares these features with related work. Section IV presents the demonstration setup and visitor experience. Section V concludes the paper.

Fig. 1. Snapshot of the simulation environment.

II. CiThruS Simulation Environment

Fig. 1 depicts a snapshot of our simulator in action. The environment is built with Unity 3D engine upon the open Windridge City Asset [4] available in the Unity Asset Store.

The vehicles use invisible rays, similar to real-life LiDAR sensors, to avoid collisions. A predetermined network of nodes is used to navigate around the scene. The pedestrians use Unity's built-in *Navigation Mesh* (*NavMesh*) approach, which calculates a suitable path in the scene automatically. This gives the impression of free-willed humans walking around the city. The 3D models for the vehicles were created in-house, the pedestrians were made with MakeHuman [5], and the animations were obtained from Mixamo [6].

The simulation features many realistic-looking scenarios found in real-life traffic such as intersections with and without traffic lights, multi-lane roads, traffic circles, and complicated junctions. In addition, a multitude of weather effects (rain, snow, and fog) and times of day have been implemented as illustrated in Fig. 2. The rain effect includes both physical rain particles and lens effects. During night-time, the scene can be illuminated with streetlamps and the vehicles have headlights.

As depicted in Fig. 3, our built-in interface contains an automatic tool to add camera arrays to the scene and capture videos from multiple viewpoints. The arrays can be attached to moving vehicles and even pedestrians. Each camera has a specific resolution and frame rate. Camera outputs contain recorded video and data file for per-frame rotation and position.

III. Comparison with Related Work

Table 1 illustrates a comparison between the existing and our simulation environments. Our lightweight approach outperforms prior-art by removing features, which are unnecessary for pure traffic imaging purposes. As a result, the simulation can maintain a stable frame rate of 60 *frames per second* (*fps*) on modern hardware.

Fig. 2. Night-time snow and daytime rain effects.

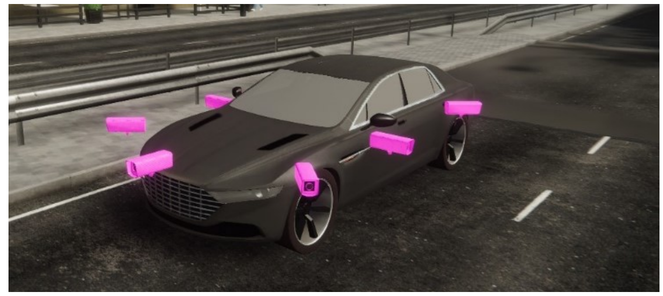

Fig. 3. Example of multiple camera output.

TABLE I. FEATURE COMPARISON OF TRAFFIC SIMULATORS

	CARLA [7]	TORCS [8]	SIRCA [9]	Proposed [3]
Lightweight		X	X	X
Optimized for traffic imaging				X
Realistic graphics	X			X
Different driving conditions	X			X
Easy multi-camera capture	*			X
Easily reconfigurable	X			X
Open source	X	X		X

* Requires extra work

CARLA (*Car Learning to Act*) [7] features more realistic vehicles and traffic conditions but is too heavy to be run in real-time due to extensive video capture from dozens of views at the same time. TORCS [8] and SIRCA [9] feature non-realistic graphics and limited configurability for our purposes. In addition, SIRCA is not available as open source. Of these approaches, only our solution supports easy video capture from multiple perspectives (Fig. 3).

IV. DEMONSTRATION SETUP AND VISITOR EXPERIENCE

Fig. 4 depicts the demonstration setup. The simulator is run in real time (60 fps) on a consumer-grade laptop having Intel Core i7 7700HQ 4-core CPU and Nvidia GTX 1060 GPU. The simulation is controlled with an Xbox –controller.

During the demonstration, visitors are able to get a realistic impression on traffic scenes and flows. They can also use an Xbox controller to fly around the scene and play, pause, and switch between different cameras in order to get a better view of the city and its surroundings. The controller can also be used to change both the time of day and the weather conditions (Fig. 2), turn on and off the streetlights, and in some cases control the headlights of a vehicle.

V. CONCLUSION

This paper presented our traffic scene simulator for testing 360-degree vision-based algorithms and related vehicular video communication in a virtual environment before putting them into practice. To the best of our knowledge, this is the first open simulator that implements realistic-looking traffic scenes and their multi-camera capture from various perspectives while being lightweight to run.

Fig. 4. Demonstration setup.

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