6. Conclusion

In this research, two distinct works have been done. In the first part, this work aimed to define a single score for various available autonomous vehicle simulators that quantifies the useability of the respective simulator to a user based on their requirements. Various available autonomous vehicle simulators and use case are studied and based on which 73 comparative parameters that can be used to distinguish various simulators have been identified. A scoring system has been devised in which each parameter can be scored in the scale of 0 to 1. The entire scoring system includes two sets of scores one for the simulator which explains the capability of the simulator for a particular called Base score and another for the user which represents the relevance of each parameter for a user and their application called user weight. The final score is derived based on these two sets of scores which represents bath simulator capability and the user’s interest. These final scores of various simulators subjected to evaluation can be used to decide the choice. The higher the score of a simulator for a user is more suitable for their choice. In this way, a systematic approach for comparison of various simulator related to autonomous driving can be done. This work can reduce the time required by the user to figure out the applicable simulator which require reading documentations, installing the simulator and using it to figure out the applicability. However, this work could create a crisp and concise version of what a simulator can offer.

The second part of the thesis focussed on the attempt to develop a simulator driven by a generative model. In this approach two core functionalities of an autonomous driving simulators are attempted to replicate. One is simulation of the sensory data to a next state based on the action taken. Another is generation of new diverse scenarios which is crucial for a training a Machine learning model which drives the car to generalize. A conditional generative adversarial network is designed and trained on the data from a mathematical model-based simulator. Sensor data from a mock 2D Lidar has been recorded and attempted to generate new instances of such data. Moreover, the trained model should model transition of sensor data over the time steps in accordance with action command represented by a 3-dimensional vector of (Turn angle, Turn direction, Velocity). The generative model can be used to drive the simulator by recursively feeding the output as input in consecutive timesteps. This generation of new scenarios can be helping the algorithms which are been trained on this simulator to generalize better and resolve the issue of lack of diverse environments in some simulators like Carla [25]. Based on the results the model effectively learns the physics of the sensor and models the transition well in accordance with the input action command. However, no new objects and their representation in the generated 2d lidar map are seen in the generated data. This could be due to lack of diversity in the training data. Moreover, noise in the generated data is observed and it is difficult to identify and quantify the realism of the generated new object in the 2d Lidar signal.

7. Future Works

In the future work for the comparative metric, system of mandatory parameters can be introduced which can represent utmost important parameter concerned to a user. If a simulator doesn’t satisfy the criterion can be excluded from the evaluation instead assigning higher weights. Furthermore, the base scores are constant for a given version of simulator so the list of base scores for a popular simulator can be made beforehand facilitates easy use of this system. New parameters can be introduce based on the user’s feedback and reviews.

In terms of sensory data generation, there are several areas that can be developed, this method of learning the transition of 2D Lidar sensor for given action command can be translated to any other sensors used in autonomous driving. In particular, this can be used to generate the image of consecutive time steps provided the prior timestep image and respective action taken at that time step. Collection of diverse datasets with various scenarios can lead to learning of that distributions and generation diverse scenarios with new objects within the generated image. Identification and quantifying the realism in the generated output is relatively easier in images than Lidar map. Furthermore, usage of certain filters like low pass filters can reduce the noise in generated output. This can prevent the accumulation of the noises in the generated outputs over the consecutive timesteps. Training the model with dataset which contain synchronized data from multiple sensors can lead the model to learn the co relation between the sensors with respect to its change in accordance with action taken, ultimately generating synchronized multiple sensory data.

CLEAN TEXT

6. Conclusion

This research includes two primary phases. The first segment aimed to establish a unified metric for evaluating the useability of diverse autonomous vehicle simulators. The objective was to quantify a simulator's usability based on user-specific requirements. An extensive study of available simulators and their respective use cases led to the identification of 73 distinct parameters for comparing these platforms. A scoring system was devised, allowing each parameter to be rated on a scale of 0 to 1.

The scoring system comprises two sets of scores: one assesses the simulator's capabilities (referred to as the Base score), while the other measures the significance of each parameter for a user and their intended application (referred to as user weight). The final score results from the combination of these two sets, offering a comprehensive representation of both simulator capability and user preferences. These final scores, generated for different evaluated simulators, serve as a basis for informed decision-making. A higher score signifies a better fit for the user's needs, facilitating a systematic comparison among various autonomous driving simulators. This approach streamlines the process of evaluating simulators, significantly reducing the time users spend navigating through documentation, installing simulators, and assessing their applicability. Moreover, it enables the creation of a precise overview of a simulator's functionalities.

The second segment of the thesis concentrated on developing a prototype simulator driven by a deep generative model. This approach aimed to replicate two fundamental functionalities of an autonomous driving simulator. Firstly, it focused on simulating the progression of sensory data to a subsequent state based on the executed action. Secondly, it aimed at generating a spectrum of novel scenarios crucial for training machine learning models to ensure their ability to generalize effectively.

The generative model's output was proposed to drive the simulator iteratively by using its own generated output as subsequent input in consecutive time steps. The scenario generation holds potential in aiding algorithms trained on this simulator to generalize more effectively, potentially addressing the issue of limited environmental diversity observed in certain simulators like Carla [25].

A conditional generative adversarial network was devised and trained using data obtained from a mathematical model-based simulator. Specifically, the network was trained on sensor data derived from a simulated 2D Lidar. The objective was to learn the transition of sensor data across multiple time steps in accordance with an action command represented by a 3-dimensional vector (Turn angle, Turn direction, Velocity). Furthermore, the trained model was intended to generate instances of such data representing plausible new scenarios.

The results indicated that the model effectively learned the physics underlying sensor and effectively modelled their data transitions in response to input action commands. However, limitations surfaced as the generated data did not introduce new objects and their representations in the 2D Lidar map. This shortcoming might stem from the lack of diversity in the training data. Additionally, noise was observed in the generated data, presenting challenges in identification and assessing the realism of newly generated objects within the 2D Lidar signal.

7. Future works

Future works regarding the comparative metric includes the potential introduction of a system that mandates parameters which are utmost crucial to users. Such mandatory parameters would signify critical criteria, and simulators failing to meet these standards could be excluded from evaluation rather than receiving higher weights. Additionally, considering that base scores remain constant for a specific simulator version, pre-establishing a list of base scores for widely used simulators would streamline the application of this evaluation system, ensuring user-friendly implementation. Moreover, the inclusion of new parameters derived from user feedback and reviews could enrich the evaluation framework, enhancing its relevance and comprehensiveness over time.

Regarding sensory data generation, there are several areas that can be improved. The methodology employed for learning the transition of 2D Lidar sensor data concerning given action commands could be extended to encompass other sensors prevalent in autonomous driving systems. Specifically, this approach could be extrapolated to generate sequential images based on prior image time steps and their respective actions. Accumulating diverse datasets across various scenarios could facilitate learning its distributions and the generation of diverse scenarios with novel objects integrated into the generated images. Evaluating and quantifying the realism of generated output is comparatively more straightforward in images than in Lidar data. Moreover, integrating specific filters such as low pass filters could diminish noise in the generated output (2D Lidar signals), preventing its accumulation across successive time steps. Training the model using datasets containing synchronized data from multiple sensors holds potential to enable the model to comprehend the correlations among sensors concerning their variations in response to actions, ultimately leading to the generation of synchronized multisensory data.