"Emulating Emergency Vehicle Navigation in Mixed Traffic Environment Using Graph Prediction and Simulation"

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PROBLEM STATEMENT

- The integration of autonomous vehicles (AVs) into our traffic networks is happening quite quickly. Although completely autonomous drivings still a ways off, in the near future, traffic will be composed of both human-driven and autonomous vehicles.
- We propose a novel method utilizing GraphSAGE and a custom action policy function for simulating Emergency Vehicles (EVs) navigation in mixed-traffic environments through SUMO simulation.

BACKGROUND

- Although many authors have addressed efficient traversal of set of cars in mixed environments through GRL , very few have focused on single vehicle,In particular, the specific scenario of emergency vehicle, In particular using Graphsage for embeddings along with link prediction would suffice solving real time scenario evaluation.
- Graph data structure better represents the traffic environment, Hence making use of Graph Neural Networks Graphsage in particular for obtaining embeddings from neighbor nodes helps in link prediction.

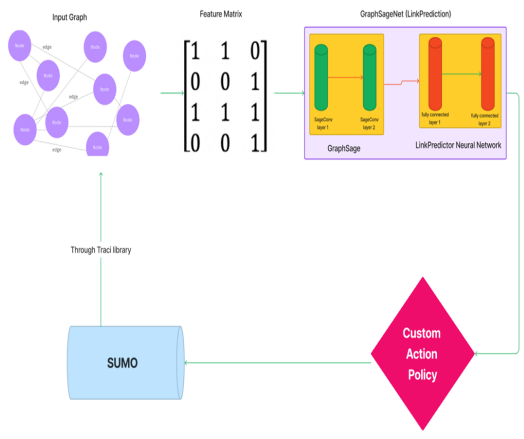
DATASET / FEATURES

- The 3 scenarios have been created namely: highway merge, intersection, and citywide. The traffic network is modeled using SUMO, and the IDM3 algorithm is used to model human-driven vehicles.
- The dataset is derived from real-life scenarios in OpenStreetMap (OSM) and recreated in SUMO traffic simulation software, incorporating vehicles. It includes vehicle ID, speed, X and Y coordinates, and Lane ID. The dataset is dynamic and serves as the basis for constructing a graph, which is then applied to the GraphSAGE algorithm to generate node embeddings for each vehicle.

DESIGN APPROACH / METHODS

- The paper presents a simulation method for Emergency vehicles(EVs) navigation in mixed-traffic environments using GraphSAGE and a custom action policy function. It uses the TraCI library to extract vehijcle attributes and creates a graph to distinguish between Human and Autonomous Vehicles
- GraphSAGE generates node embeddings, while LinkPredictorNN predicts missing links.The custom action policy function determines vehicle scores,prompting speed adjustments for efficient navigation

ARCHITECTURE



RESULTS / DISCUSSION

- The study presents a new approach to traffic graph optimization that doesn't require high GPU hardware processing power and doesn't require large-scale calculations..
- The intersection scenario showed a more noticeable optimization , possibly due to the increased mutual influence between cars. The custom action policy function significantly outperformed the baseline when combined with the graph for the city network, indicating GraphSAGE's strong prediction abilities. Merge network showed a relatively sparse distribution of cars, suggesting that individual vehicle driving behavior has little effect on traffic flow.

OUTCOME / SUMMARY

- The research introduces an emergency vehicle navigation approach that eliminates the need for high GPU processing power. The custom action policy function produces concise actions without large-scale calculations.
- The approach outperforms the baseline in city networks and GraphSAGE for link prediction. In merge scenarios, the GraphSAGE-based approach improves significantly. The combination of a graph and custom action policy function enhances simulation efficiency

CONCLUSION / FUTURE WORK

- The paper presents a novel approach to EV navigation using GraphSAGE and a custom action policy function. It improves EV navigation efficiency by capturing traffic dynamics and optimizing traffic flow. The method offers benefits over traditional RL-based techniques, especially in emergency vehicle navigation. Future research will be to explore architectures, action policy functions, and traffic scenarios. In addition including RL algorithms and focusing on traversal of set of EV's.

Table 3. Performance on Intersection

Simulation Scenario	Parameters		
	Emergency Waiting Time	*Depart Delay*	*Average Waiting Time*
Baseline	9.3s	2.4s	15.8s
Graph made by simulation attributes	3.6s	0.2s	3.2s
Graph made by GraphSAGE	3.8s	0.5s	3.1s

REFERENCES

- [1] Liu, Tao, Aimin Jiang, Jia Zhou, Min Li, and Hon Keung Kwan. "GraphSAGE-Based Dynamic Spatial–Temporal Graph Convolutional Network for Traffic Prediction." *IEEE Transactions on Intelligent Transportation Systems* (2023).

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