Demystifying AI for Transportation Planners: Bridging Research and Practice

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Agenda

- Introduction
- The Architecture of Open-TI
- Sub-module Embodiment
- Experiment
- Acknowledgments

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Introduction

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Introduction

How to bridge that gap?

- **Unifying the simulation and analysis process** by a standard ecosystem like General Modeling Network Specification (GMNS) to define a common format for sharing routable road network files and is designed for multi-modal static and dynamic transportation planning and operations.

- **Building an intelligent system with self-explain abilities**, which is integrated with multiple domain-specific tasks and the corresponding frontier solutions: state-of-the-art algorithms, powerful simulators, etc., and can be easily executed with sufficient explanations in an interactive way.

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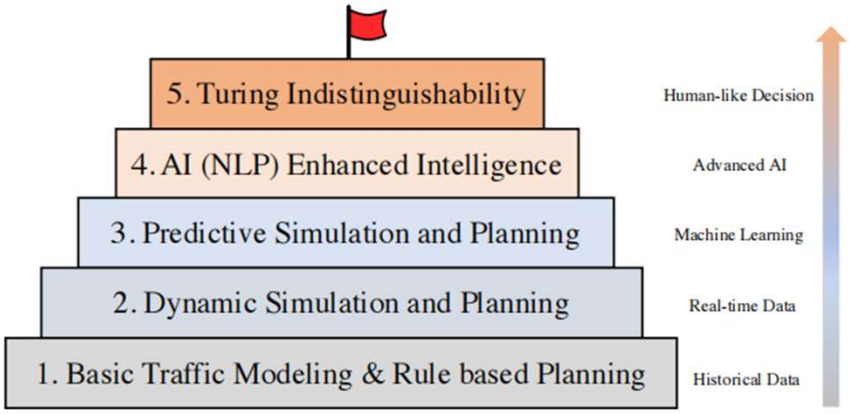
Introduction

5 stages of Transportation intelligence:

Transportation intelligence develops across five stages, from rule-based modeling to dynamic and predictive simulation, AI-enhanced intelligence, and ultimately Turing Indistinguishability with human-like decision-making.

Large language models (LLMs) advance stage four, while Augmented Language Models (ALMs) extend tool use and analysis.

We propose Open-TI, a prototype traffic agent combining dialogue, intent understanding, analysis, and interpretability for research and practice.



Source: Open-TI

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The Architecture of Open-TI

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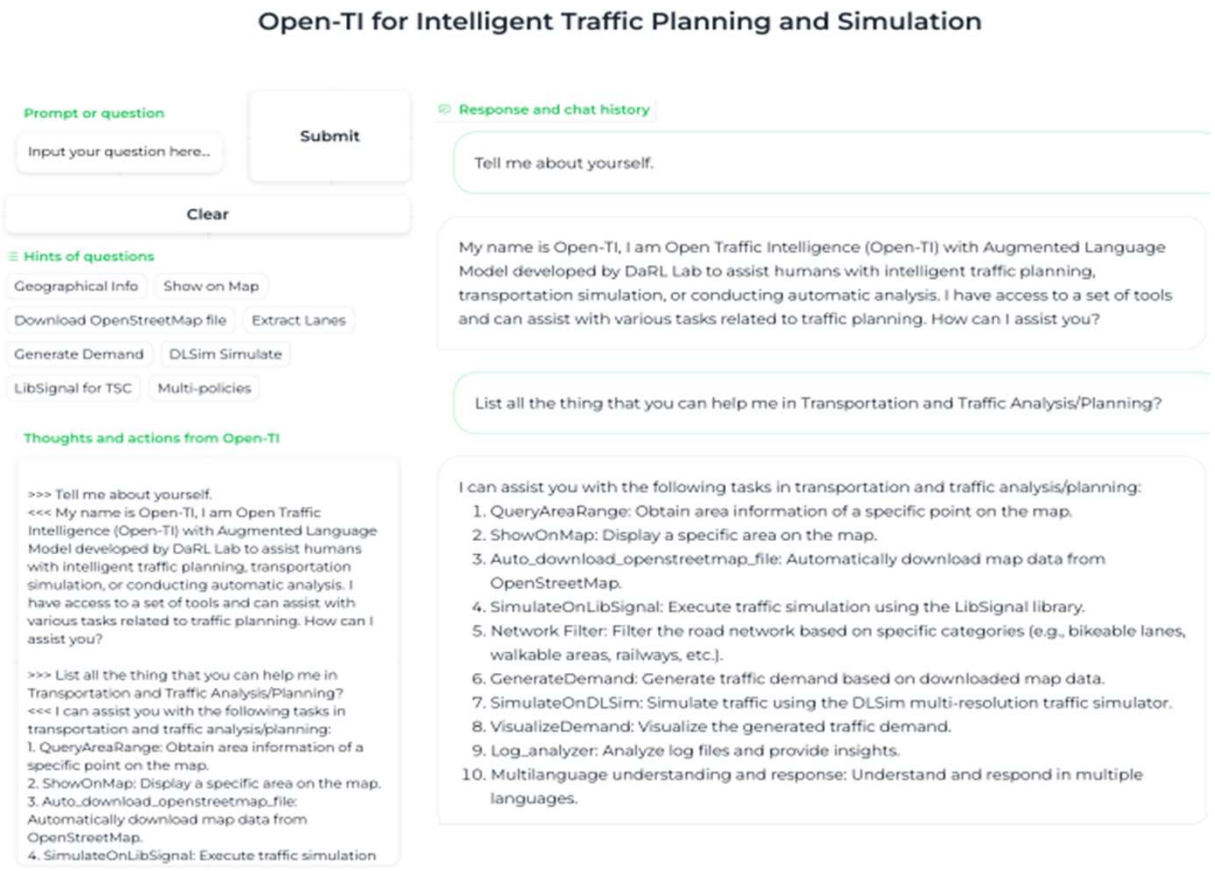
Overview of Open-TI



- **Prompt or question** (top left)
- **Hints of questions** (middle left)
- **Thought and action**
- **Response and chat history**

Reference: Da, L., Liou, K., Chen, T., Zhou, X., Luo, X., Yang, Y., & Wei, H. (2024). Open-ti: open traffic intelligence with augmented language model. Int. J. Mach. Learn. & Cyber.

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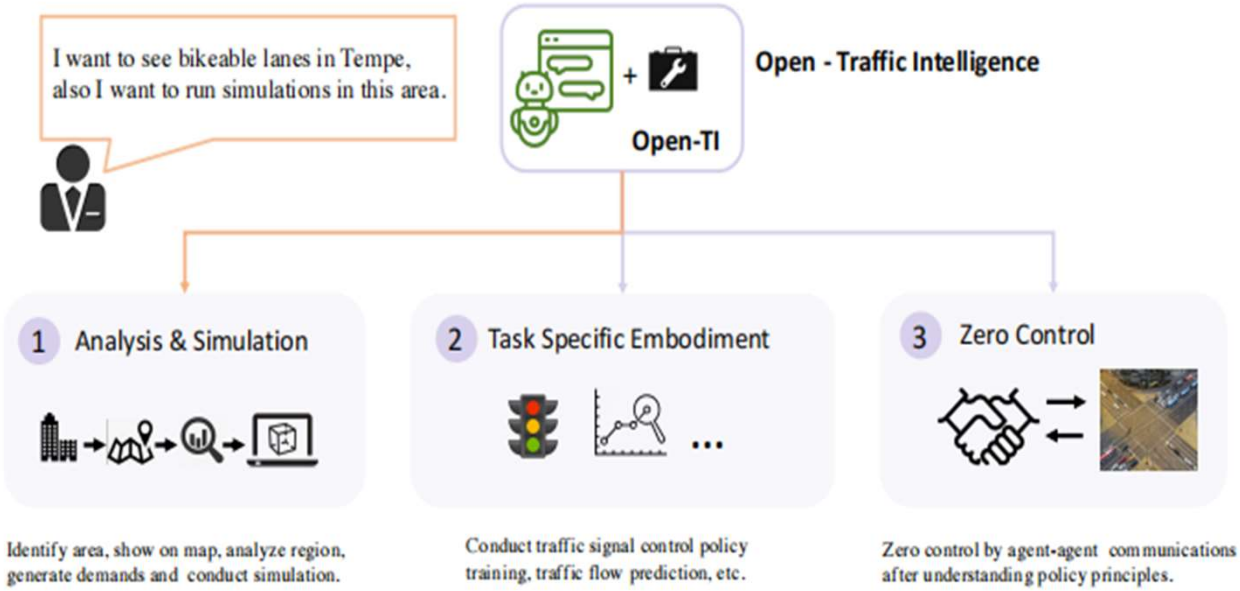
Overview of Open-TI

The core of Open-TI mainly incorporates three modules: **Analysis and Simulation**, **Task Specific Embodiment** and **Zero Control** to enhance the intelligent traffic analysis and planning.



Source: Open-TI

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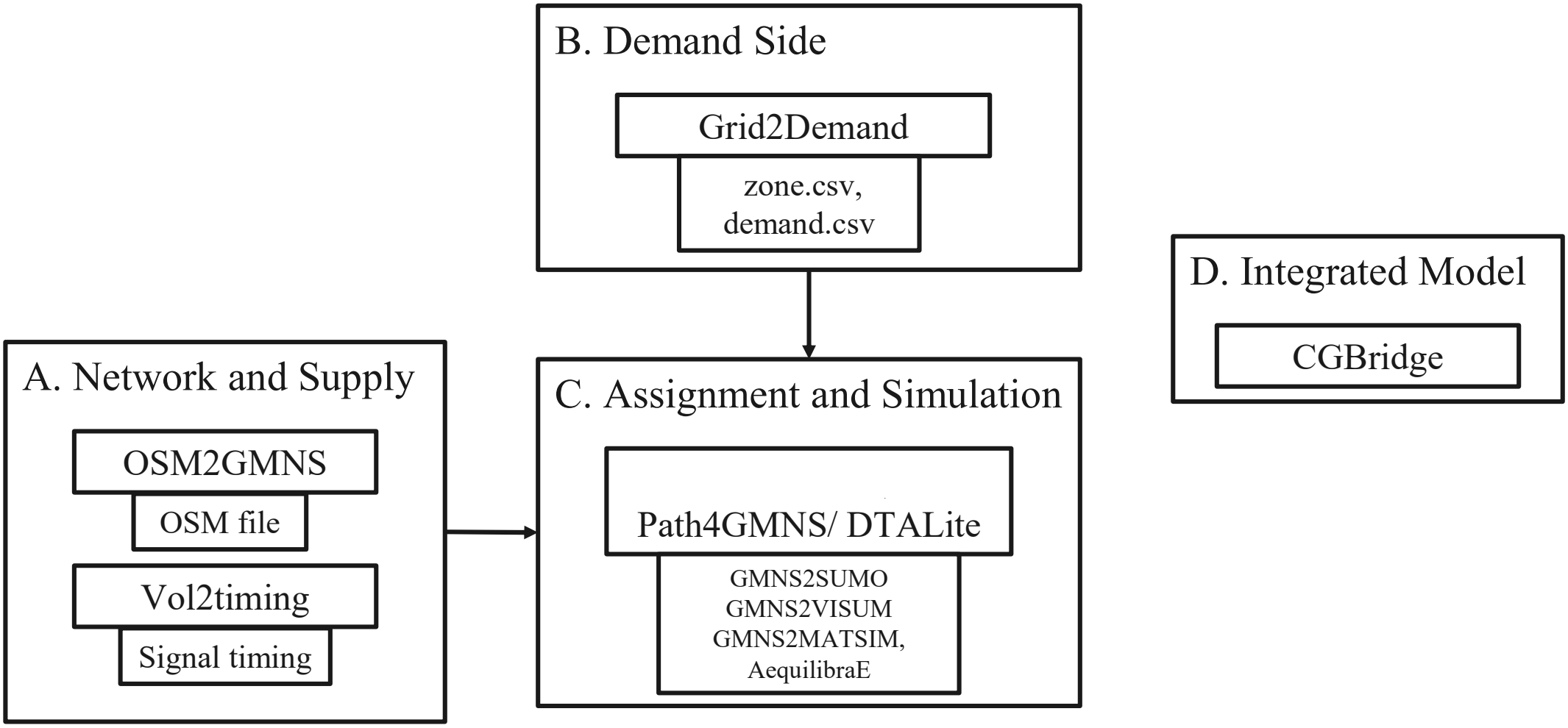
Integrate Network, Demand and Supply Elements based on GMNS



Source: ASU Trans+AI Lab. https://github.com/asu-trans-ai-lab

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Open-Source Ecosystems

Download OSM data
https://osm2gmns.readthedocs.io/en/latest/quick-start.html

Get a network in GMNS format

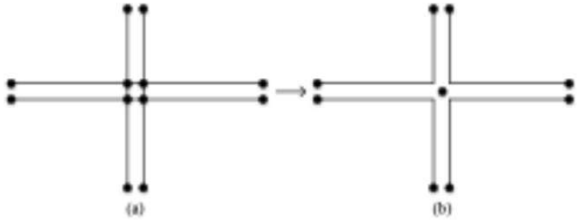
```
>>> import osm2gmns as og
>>> net = og.getNetFromFile('asu.osm')
>>> og.outputNetToCSV(net)
```

Consolidate Intersections

```
>>> og.consolidateComplexIntersections(net)
```

Generate movements at intersections

```
>>> og.generateMovements(net)
```



Network Types and POI

```
>>> net = og.getNetFromFile('asu.osm', network_types=('auto','railway','aeroway'))

>>> net = og.getNetFromFile('asu.osm', POI=True)

>>> og.connectPOIWithNet(net)
```

Source: ASU Trans+AI Lab. https://github.com/asu-trans-ai-lab

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Sub-module Embodiment

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Pivotal Agent for Transportation Analysis

In this module, analysis is enabled through seamless integration of augmented tools with the core operation agent. When users request related tasks, Open-TI automatically selects the most suitable option, as illustrated in the example.

The supported external tools and packages are shown as follows:

Name	Functions	Versions
osm2gmns	obtain networks from OSM and convert to GMNS	V-0.7.3
grid2demand	Origin-destination trans demand generate	V-0.3.6
DLSim-MRM	Multi-resolution Traffic Simulation	V-0.2.11
Libsignal	Multi-simulator platform for Traffic Signal Control	V-1.0.0

Source: ASU Trans+AI Lab. https://github.com/asu-trans-ai-lab

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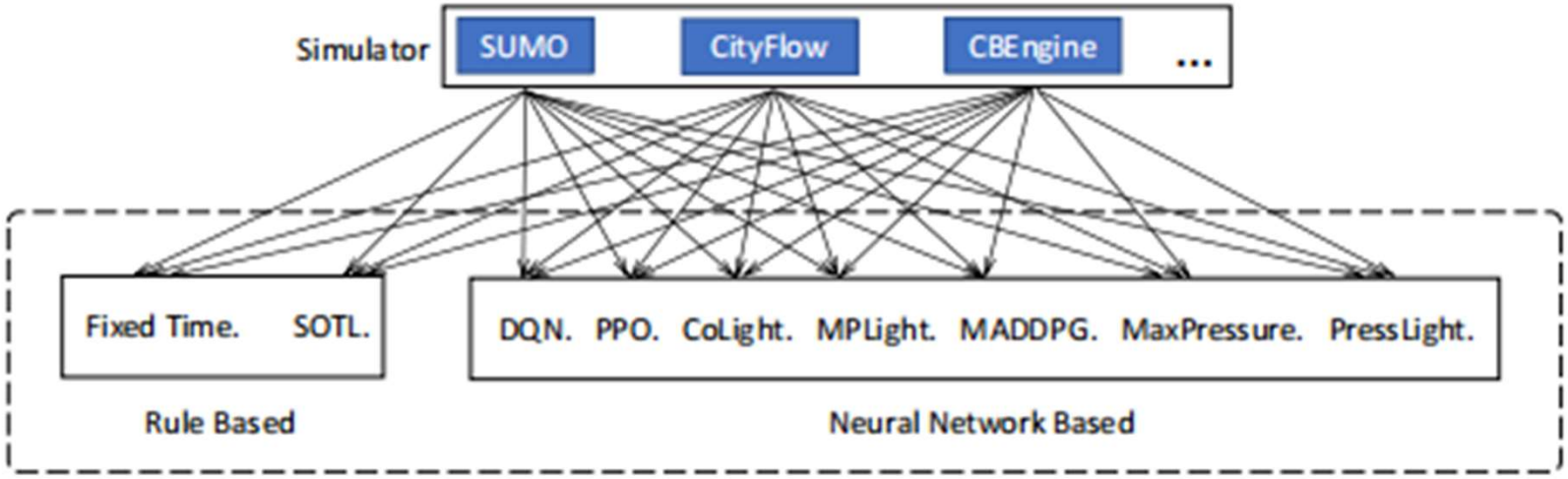
Task-Specific Embodiment

In the realization of traffic signal control embodiment, we seamlessly integrated the Libsignal that could realize the cross-simulator traffic signal control over the majority of baseline methods, including the rule-based approaches (Fixed Time and Self-organizing traffic lights - SOTL) and reinforcement-learning-based approaches as shown below.



Source: Open-TI

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Experiment

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Language Agent Analysis on the API Calls

We conduct the functionality-level experiments of API analysis and compare them with the baseline method known as TrafficGPT.

Experiment Design:
First, we analyze three types of API call abnormal behaviors, namely '**No API Call Rate**', '**API Mismatching Rate**', and **'Error Raise Rate**'. Both Open-TI and TrafficGPT are equipped to handle a range of tasks spanning geographical information, simulation, and traffic signal control. Although the specific functions of Open-TI and TrafficGPT are slightly different, we are still able to evaluate the overall API access stability. We adopted T = 6 similar tasks to conduct the comparison by testing each task 20 times. And calculate the error rate follow the equation 1:

$$Error\ rate = \frac{1}{T}\sum_{t=1}^{T}\frac{n_t^e}{n_t^c} = \frac{1}{T}\sum_{t=1}^{T}\frac{1}{n_t^c}\sum(c_t^{no}, c_t^{miss}, c_t^{error}) \quad (1)$$

where n_t^e represents the number of error occurrences for task t during total tests, nc denotes the number of total testing instances, (i.e., n_c = 20 for this experiment), c_t^{no} is the sum of errors caused by the absence of API calls for task t among all tests, similarly, c_t^{miss} is the sum of mismatching error times, c_t^{error} is the number of error raising times, and exist $n_t^e = c_t^{no} + c_t^{miss} + c_t^{error}$.

Reference: Da, L., Liou, K., Chen, T., Zhou, X., Luo, X., Yang, Y., & Wei, H. (2024). Open-ti: open traffic intelligence with augmented language model. Int. J. Mach. Learn. & Cyber.

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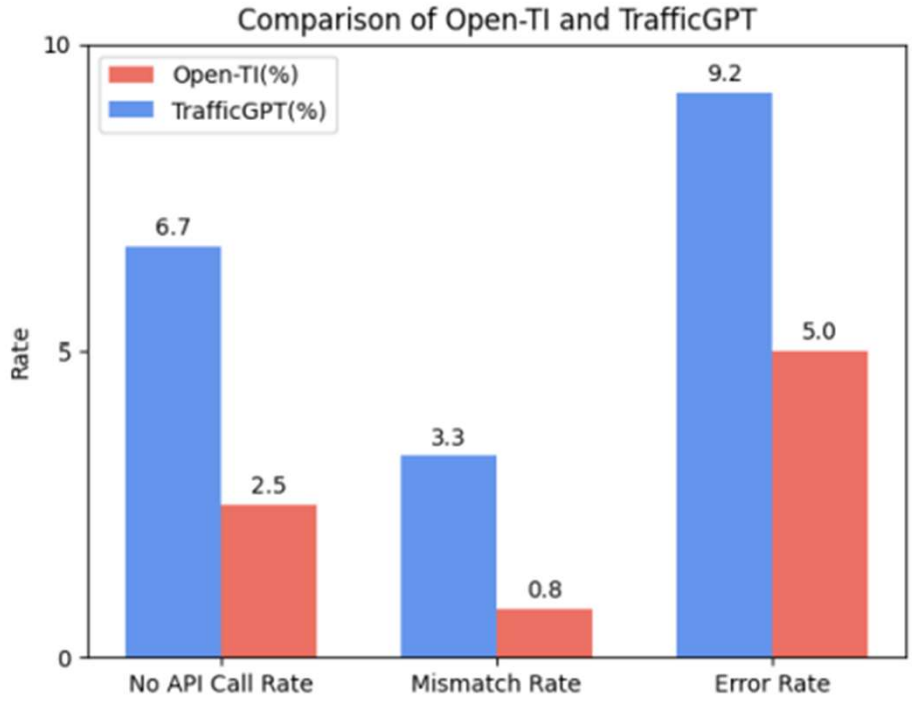
Language Agent Analysis on the API Calls

The comparison is conducted on the average value over 20 times. The sum of the 3 types of error rates in Open-TI and TrafficGPT are 8.3% and 19.2%, calculated by aggregation of the three types of error rates in two systems respectively.



Source: Open-TI

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Acknowledgments

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Acknowledgments

Longchao Da, Kuanru Liou, Tiejin Chen

Dr. Yezhou Yang, Dr. Hua Wei

School of Computing and Augmented Intelligence,
Arizona State University (USA)

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School of Sustainable Engineering and the Built Environment,
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Key Tools and Resources

- **osm2gmns (PyPI)**
https://pypi.org/project/osm2gmns/
A high-performance package to convert OpenStreetMap (OSM) data into standardized GMNS transportation networks.

- **path4gmns (PyPI)**
https://pypi.org/project/path4gmns/
An efficient framework for path-based modeling, supporting shortest paths, demand modeling, and related applications.

- **DTALite (GitHub)**
https://github.com/asu-trans-ai-lab/DTALite
An open-source AMS library for macroscopic and mesoscopic traffic assignment using GMNS format.

- **grid2demand (GitHub)**
https://github.com/asu-trans-ai-lab/grid2demand
A tool for generating zone-to-zone travel demand based on grid cells or TAZs using a gravity model.

- **Reference Paper:**
Da, L., Liou, K., Chen, T., Zhou, X., Luo, X., Yang, Y., & Wei, H. (2024). Open-TI: Open traffic intelligence with augmented language model. International Journal of Machine Learning and Cybernetics.

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THANK YOU

ASU Trans+AI Lab

Lab Website: https://github.com/asu-trans-ai-lab

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