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AUTOMATING TRAFFIC MICROSIMULATION FROM SYNCHRO UTDF TO SUMO

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ABSTRACT

Modern transportation research relies on seamlessly integrating traffic signal data with robust network representation and simulation tools. This study presents utdf2gmns, an open-source Python tool that automates conversion of the Universal Traffic Data Format, including network representation, signalized intersections, and turning volumes into the General Modeling Network Specification (GMNS) Standard. The resulting GMNS-compliant network can be converted for microsimulation in SUMO. By automatically extracting intersection control parameters and aligning them with GMNS conventions, utdf2gmns minimizes manual preprocessing and data loss. utdf2gmns also integrates with the Sigma-X engine to extract and visualize key traffic control metrics, such as phasing diagrams, turning volumes, volume-to-capacity ratios, and control delays. This streamlined workflow enables efficient scenario testing, accurate model building, and consistent data management. Validated through case studies, utdf2gmns reliably models complex urban corridors, promoting reproducibility and standardization. Documentation is available on GitHub and PyPI, supporting easy integration and community engagement.

1. INTRODUCTION

Traffic microsimulation is essential for evaluating and enhancing urban transportation systems, providing insights into traffic flow management, congestion mitigation, and infrastructure improvements. Accurate simulations require precise representation of traffic signals, network geometries, and turning movements. However, conventional approaches to preparing simulation-ready networks, particularly from popular tools such as Synchro, remain largely manual and error-prone. Synchro's Universal Traffic Data Format (UTDF) provides comprehensive intersection data but lacks efficient interoperability with microsimulation software, leading to labor-intensive data preparation, potential inaccuracies, and inconsistencies.

Several critical challenges persist in effectively converting Synchro UTDF data into microsimulation-compatible networks, such as those used by Simulation of Urban Mobility (SUMO) (Lopez et al. 2018). One primary challenge is signal conversion. Translating intersection control parameters accurately into standardized formats involves detailed extraction, interpretation, and alignment of signal phasing, timing, and coordination data. Inaccuracies in this step can significantly affect the reliability of simulation outputs, underscoring the necessity for precise and automated methods. Another substantial challenge involves network conversion. Synchro typically uses relative coordinate systems, which must be converted into real-world geographic coordinates (longitude and latitude) for effective integration with Geographic Information Systems (GIS). This conversion process is often tedious, error-prone, and requires considerable manual effort, complicating large-scale or complex network simulations. Additionally, accurate turning flow conversion is essential for realistic simulation of intersection dynamics. Converting turning movement data, which is crucial for capturing the complexity of urban traffic interactions, frequently involves extensive manual preprocessing. Imprecise conversion in this stage can propagate through simulations, compromising the accuracy and usefulness of the resulting analyses.

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Existing research and implementations have not yet provided comprehensive solutions to all the identified challenges simultaneously. Zhang (2024) introduced a method to convert Synchro signal data to a SUMO network; however, this conversion requires preliminary preparation of both the Synchro UTDF file and the SUMO network separately. Ban (2022) converted Synchro signal data into SUMO to facilitate calibration within a vehicle-traffic-demand (VTD) simulation platform; however, the networks used in Synchro and SUMO were prepared independently and differently. Coogan (2021) conducted an early effort to convert Synchro's geometric and phasing data into SUMO, primarily emphasizing geometry conversion. Nevertheless, their network conversion employed relative coordinates and was limited to selected intersections, lacking automation and scalability for broader applications. Udomsilp (2017) leveraged Synchro for optimizing network signal timings, specifically cycle lengths, and subsequently employed these optimal cycle lengths as inputs into SUMO simulations to evaluate travel-time improvements. Similarly, Singh (2017) used Synchro for traffic signal optimization, incorporating optimal green times into SUMO simulations to assess start-up lost times. Despite these contributions, a fully integrated and automated solution remains lacking in current literature.

To address these gaps, we introduce utdf2gmns (Luo and Zhou 2022), an open-source Python tool (Figure 1) that automates the conversion of Synchro UTDF files into GMNS-compliant (General Modeling Network Specification) networks (Smith et al. 2020), which can then be readily transformed into simulation-ready networks for the widely used simulator SUMO. By combining the advantages of the GMNS, a robust framework that standardizes network representation (Berg et al. 2022; Lu and Zhou 2023; Luo et al. 2024; Luo 2024) and enhances data consistency, reproducibility, and collaboration, utdf2gmns specifically contributes through the following functionalities: (1) Automatic geocoding of Synchro networks, automates the transformation of relative coordinates into precise longitude and latitude, significantly reducing manual effort and ensuring accurate spatial representation. (2) Enhanced Sigma-X (SIGnal Modeling Application for eXcel) engine integration, leverages the Sigma-X engine (Bundy and Wallen 1984; Zlatkovic 2022) to automatically extract, calculate, visualize, and optimize essential signalized intersection metrics. This includes detailed phasing diagrams, turning volume statistics, movement capacities, volume-to-capacity (V/C) ratios, and intersection control delays, providing comprehensive analysis and facilitating informed decision-making. (3) Robust SUMO network generation; utdf2gmns carefully generates GMNS-compliant SUMO simulation networks by fully considering critical parameters such as signal coordination, traffic flows, and turning movements, thus accurately reflecting real-world operational scenarios. (4) Extendibility to other microsimulation platforms; built as an open-source modular tool, utdf2gmns enables easy adaptation and extension to additional simulation software platforms beyond SUMO. This promotes broader standardization, reproducibility, and community-driven enhancement in traffic simulation research.

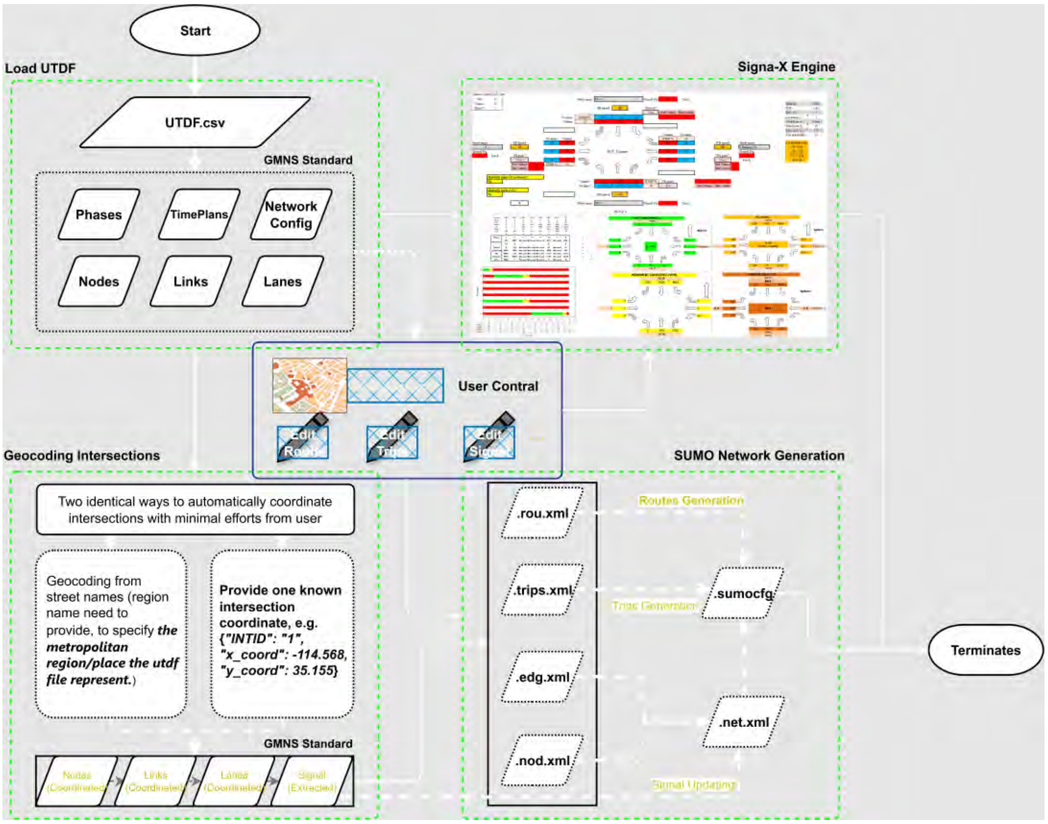


Figure 1: Design framework of utdf2gmns and methods of coordinating intersections.

2. METHODOLOGY

To accurately and automatically convert Synchro networks (in UTDF format) into SUMO for extended microsimulation, several critical aspects must be addressed. These include converting the original network coordinates from relative to real-world geographical coordinates (longitude and latitude), extracting and translating signal information from the original files into SUMO-compatible formats, converting turning flow data, and calculating essential performance metrics. The methods presented in this chapter aim to systematically resolve these issues.

2.1 Network Coordinating

The first and most critical step in the automation process is converting the Synchro network into a real-world network that can be accessed using GIS and other simulation software. In this section, we introduce two methods to transform the original network into a universally readable format (GMNS). The first method automatically geocodes intersections, while the second method requires manually inputting the coordinate of one intersection.

2.1.1 Automatic Geocoding

The UTDF file provides link names in the network. The logic for coordinate validation (Figure 2) involves iterating through each intersection and extracting directional link names, then applying a double-confirmation approach to validate the intersection's coordinates. If one valid coordinate for an intersection is confirmed, the iteration stops; otherwise, the process continues to the next intersection. In the worst scenario, where no coordinates are identified, the program will prompt the user to confirm the network's location or switch to the manual geocoding method. After successfully validating coordinates for one intersection, all remaining intersections are mapped by converting their relative coordinates into real-world positions based on the validated reference point.

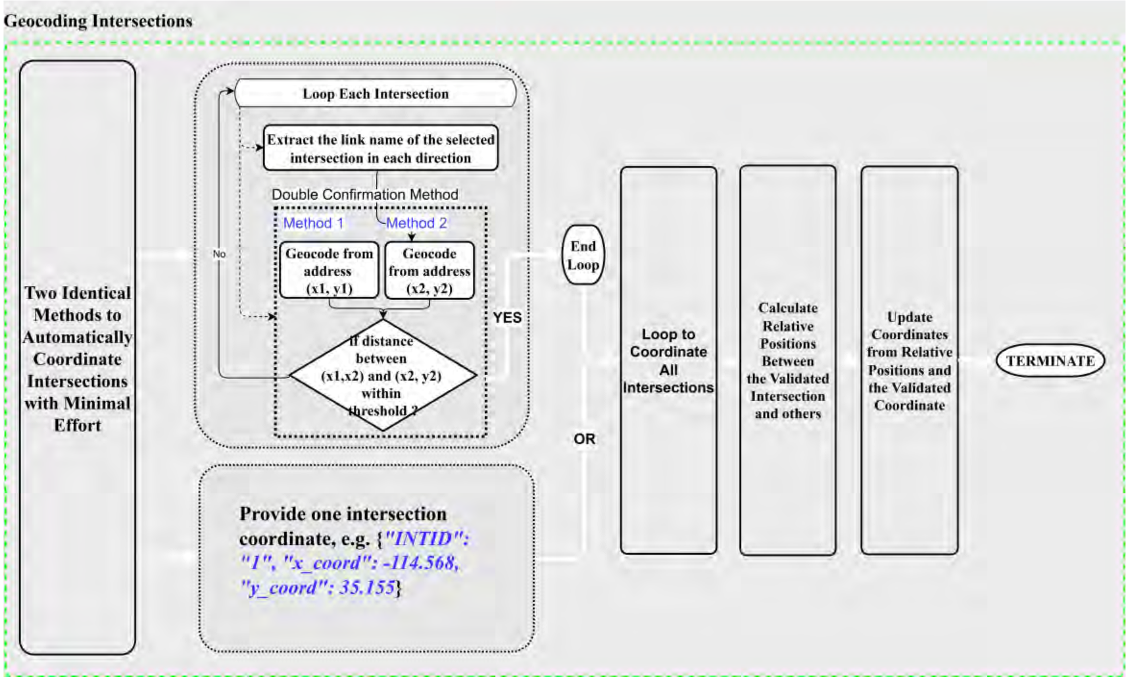


Figure 2: Methods of coordinating intersections.

2.1.2 Manual Geocoding with One Given Coordinate

Manual geocoding requires minimal effort, as only one coordination is necessary. In this step, users need to provide a single intersection ID paired with its coordinates ("INTID": intersection ID, "x_coord": longitude, "y_coord": latitude). As illustrated in Figure 2, once the coordinate of one intersection is confirmed, the program uses this reference point to geocode all other intersections accordingly.

2.2 Signal Integration

Signal information is essential for microsimulation, and accurately converting signal data from Synchro to SUMO plays a critical role in the automation process. Properly converted signals enable SUMO to use its extensive functionalities for traffic control and optimization. This paper extracts detailed signal information, including Phases, Timeplans, and Lanes from the UTDF file (Zhang 2024). Two key concepts guide the signal conversion: network direction mapping and phase mapping. For direction mapping, Synchro uses predefined movement directions (Figure), whereas SUMO represents traffic signals as state-based strings, with each character indicating specific lane-to-lane movements. Regarding phase mapping, Synchro employs a Ring-and-Barrier Designer, automatically managing signal transitions based on Barrier, Ring, and Position (BRP) assignments. In contrast, SUMO encodes signal states as strings indicating signal colors, Green (G/g), Yellow (y), and Red (r), with uppercase denoting protected and lowercase indicating permitted movements. SUMO supports various signal controllers, including pre-timed, actuated, and NEMA-type Dual-Ring-Barrier controllers (Schrader et al. 2022; Halbach and Erdmann 2022).

Direction mapping approach converts edge slopes into directions compatible with Synchro and associates this information with SUMO. The vehicular movement directions in SUMO are then determined by combining turning directions from connection data with previously assigned directional information, prioritized in the order of right turn (r), through (t), and left turn (l). Phase mapping methodology is demonstrated using a Ring-Barrier-Controlled signal. The process begins by extracting all valid phases from Synchro. A Breadth-First Search (Bundy and Wallen 1984) algorithm is then applied to identify feasible combinations of green phases. Synchro phase numbers are translated into SUMO lane-based signal states using Connection-to-Direction mapping, which aligns SUMO's link indices with the corresponding Synchro Lane groups. Finally, bitwise comparisons between adjacent green phases are conducted, with yellow and all-red phases interpolated to ensure smooth phase transitions and accurate signal timing.

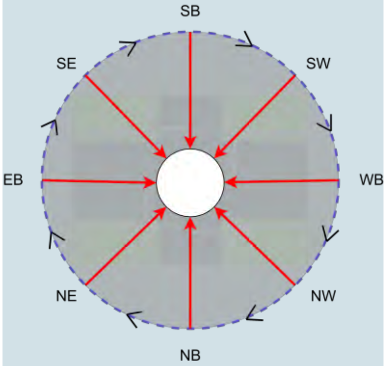


Figure 3: Direction order in synchro.

2.3 Traffic Demand Conversion

Turning volumes from the UTDF file are indicated in vehicles per hour. In Synchro, turning volumes are specified individually for each direction (Left, Through, Right, and U-Turn). However, SUMO automatically generates U-turn volumes for all possible connections, which could negatively affect the accuracy of the network conversion. To address this, we allow U-turns in the converted SUMO network only if they are explicitly specified in the UTDF file. In this section, we extract left, through, and right turning volumes from the UTDF file and generate the corresponding flow files for SUMO.

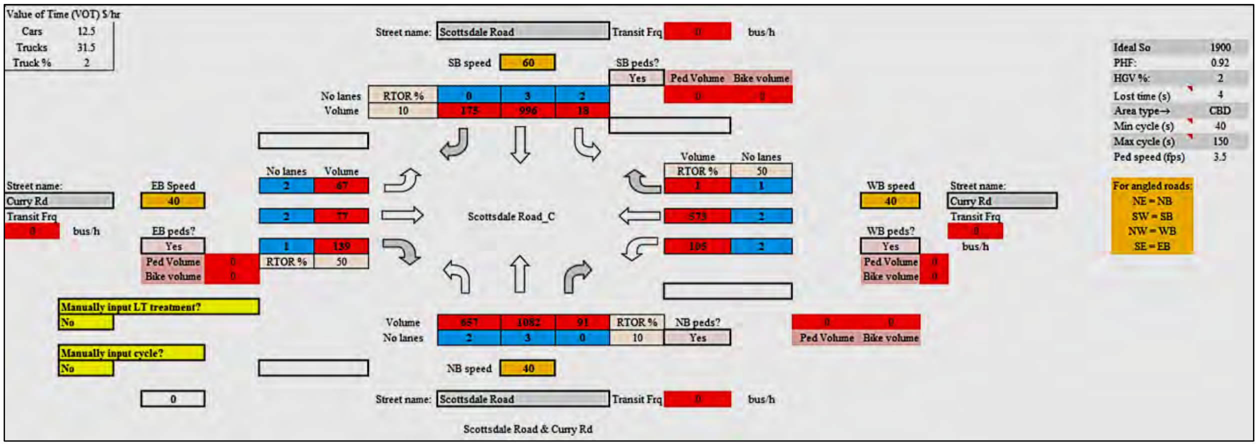
2.4 Sigma-X Powered Performance Calculation

Sigma-X is a powerful engine developed in VBA (Visual Basic for Applications) by Prof. Milan Zlatkovic at the University of Wyoming, originally created between 2012 and 2022 under a GNU License. Development resumed in 2025 by us to address challenges in handling large and complex networks and to improve result generation and management. The tool extracts key data such as signal timings, inbound and outbound flows, and links and lanes configurations. It calculates and visualizes critical performance metrics for signalized intersections, including volume-to-capacity (V/C) ratios, Level of Service (LOS), turning volumes, signal phasing, control delays (in seconds), split durations, movement capacities (vehicles per hour), and more. Additionally, Sigma-X can optimize existing signal timings and update the corresponding performance metrics in real time.

2.4.1 Overview of Signalized Intersection

The overview of the signalized intersection will combine extracted and calculated parameters into one figure with an intersection name at its center. Figure shows the sample overview features. As shown in the figure, the center is the intersection name, which is surrounded by turning movements of each approach.

The numbers of lanes and volumes correspond to each movement and will be updated from UTDF data. The right turns on red (RTOR) is specified for each right turn lane. Approach-specific speed, such as EB Speed, WB Speed, NB Speed and SB Speed, will be updated as well. For each direction, the street name will also be updated.



Value of Time (VOT) $/hr	
Cars	12.5
Trucks	31.5
Truck %	2

Street name: Scottsdale Road
Transit Frq 0 bus/h
SB speed 60
SB peds? Yes

Ped Volume	Bike volume
0	0

No lanes	RTOR %	0	3	2
Volume	10	175	996	18

Ideal So	1900
PHF:	0.92
HGV %:	2
Lost time (s)	4
Area type→	CBD
Min cycle (s)	40
Max cycle (s)	150
Ped speed (fps)	3.5

For angled roads:
NE = NB
SW = SB
NW = WB
SE = EB

Street name: Curry Rd
Transit Frq 0 bus/h
EB Speed 40
EB peds? Yes
Ped Volume 0
Bike volume 0

No lanes	Volume
2	67
2	77
1	139
RTOR %	50

Scottsdale Road_C

Volume	No lanes
RTOR %	50
1	1
573	2
105	2

WB speed 40
Street name: Curry Rd
Transit Frq 0 bus/h
WB peds? Yes
Ped Volume 0
Bike volume 0

Manually input LT treatment?
No

Manually input cycle?
No

0

Volume	657	1082	91	RTOR %
No lanes	2	3	0	10

NB peds? Yes

0	0
Ped Volume	Bike volume

NB speed 40
Street name: Scottsdale Road
Transit Frq 0 bus/h

Scottsdale Road & Curry Rd

Figure 4: Overview of the signalized intersection.

2.4.2 Signal Phasing

Phasing information is extracted from the UTDF file, which includes cycle lengths, phase splits, offsets, and protected/permissive movements. We parse these raw data to reconstruct each intersection's signal logic and reveal how phases are coordinated across the network. The processed phasing data are then used to create phase timing charts that show the sequence and duration of each phase within a cycle, highlighting overlaps and coordination opportunities with adjacent intersections. These charts both verify timing consistency and enable further analysis, such as delay estimation, progression assessment, and scenario-based simulation under different traffic conditions.

2.4.3 Turning Volume

Turning volume data captures directional vehicle flows at intersections, revealing intersection-level traffic dynamics. We visualize these volumes in movement-specific charts that show flow intensity by direction. These charts highlight demand imbalances, potential bottlenecks, and critical turning movements that may require signal timing changes or geometric adjustments. By presenting the data clearly, this analysis enables more informed decisions on traffic signal optimization and intersection design.

2.4.4 V/C Ratio and Movement Capacity

The Volume-to-Capacity (V/C) ratio is calculated from UTDF file data to quantify intersection saturation: higher ratios indicate that demand is nearing or exceeding capacity, signaling potential congestion. In parallel, movement capacity (saturation flow rate) is evaluated to determine the maximum number of vehicles each approach can handle based on existing signal timing and geometry. We generate visual charts illustrating computed V/C ratios across intersection movements. These charts highlight critical approaches where demand approaches or surpasses capacity, making it easier to spot potential delays or capacity shortfalls. By integrating movement capacity analysis, we gain deeper insight into each intersection's operational limits. The clear visualization of V/C performance serves as a diagnostic tool to quickly identify problematic intersections within the network. This supports data-driven prioritization of interventions, such as signal timing optimization, capacity enhancements, or geometric redesigns, to alleviate congestion and inform efficient resource allocation.

2.4.5 Level of Service and Control Delay

Level of Service (LOS) is a standardized metric used to evaluate the performance of signalized intersections, representing the quality of traffic flow experienced by drivers. It is categorized from A to F, with LOS A indicating minimal delays and optimal efficiency and LOS F reflecting severe delays and breakdown conditions. In this study, LOS is determined following the methodologies outlined in the Highway Capacity Manual (HCM 6th Edition), which defines LOS based on control delay per vehicle measured in seconds, the additional time a vehicle spends at an intersection compared with uninterrupted flow. Using data including approach volumes, lane configurations, and signal timing, control delays are computed, and LOS values are assigned to each approach and intersection accordingly. The results are visualized through clear, data-driven charts that highlight operational efficiency across the network. These visualizations not only convey overall intersection performance but also pinpoint specific areas where high control delays (e.g., LOS E or F) occur. This enables traffic engineers to identify critical problem areas and implement targeted interventions such as signal retiming, lane reconfigurations, or capacity enhancements to improve overall network performance.

2.4.6 Split Durations

Split duration refers to the allocation of cycle time among signal phases at an intersection, directly influencing performance, vehicle delay, and traffic progression. In this study, we extract and calculate split durations to generate charts showing how green time is distributed across movements within each cycle. These visualizations reveal mismatches between signal timing and traffic demand, highlighting phases that receive too much or too little green time. By identifying these inefficiencies, the analysis supports data-driven adjustments to signal timing plans, enabling more effective use of intersection capacity and promoting smoother, balanced traffic flow.

2.5 SUMO Simulation Generation

The generation of a SUMO simulation from a Synchro-based model involves a multi-step automated process using SUMO's *netconvert* and *jtrrouter* tools. The workflow begins with the geocoding of intersections, which provides the foundation for deriving the geometry and structure of links and lanes. Using the geocoded intersection data, the corresponding link and lane files are generated to define the physical and directional attributes of the network. Once these spatial components are created, they are integrated using the *netconvert* tool to produce a base network file (net.xml) in SUMO format. Following network construction, the next critical step is the integration of traffic signal information. This involves mapping detailed signal phasing and timing data (previously extracted from Synchro UTDF files) into SUMO-compatible formats, ensuring accurate representation of signalized intersections. Subsequently, turning movement data is processed and converted into vehicle flow definitions, enabling the simulation of realistic traffic patterns. These flows are configured to match the geometric and signal characteristics of the network. Finally, a comprehensive SUMO configuration file (.sumocfg) is generated to coordinate all components of the simulation, including network files, route files, and signal definitions. This structured pipeline enables a seamless transformation from planning-level Synchro models to microsimulation-ready SUMO environments.

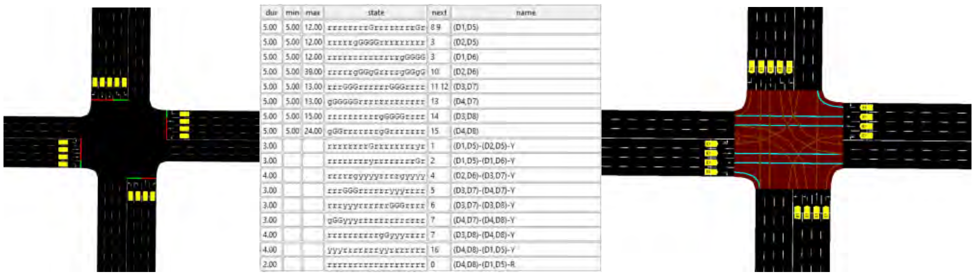
2.5.1 Network Conversion

To convert the GMNS-based network into a SUMO-compatible format, we begin by transforming real-world intersection coordinates into UTM format, as required by SUMO, which uses meters (m) and meters per second (m/s) for distance and speed units. Using these converted coordinates and associated speed data, we generate the nod.xml file representing node (intersection) information. Lane and link data, including turning movements, are then processed to create edg.xml, with each lane indexed per SUMO's convention, starting from the right-most lane as index 0. Lanes are grouped to form links, and directional flow is preserved during this process. The con.xml file is then created to define connections between edges and lanes, including turning relationships, which are critical for modeling intersection behavior.

Once the base files (nod.xml, edg.xml, con.xml, and add.xml) are automatically generated, we integrate loop detector information from the original lane data, particularly important for signalized intersections, to enhance traffic simulation accuracy. These files are then passed to the SUMO *netconvert* tool, which compiles them into a unified net.xml file representing the complete traffic network. This structured approach enables automated, scalable, and accurate network conversion from GMNS/UTDF data into SUMO format.

2.5.2 Signal Integration

At this stage, the generated net.xml file does not yet contain signal control information for signalized intersections. Signal integration is carried out by incorporating the extracted and converted signal data into the existing network structure. This process updates the net.xml file to include detailed signal configurations based on the previously processed timing and phasing data. As illustrated in Figure , signal control logic is successfully embedded into the appropriate intersections, enabling accurate representation of real-world traffic signals within the SUMO network.



dur	min	max	state	next	name
5.00	5.00	12.00	rrrrrrrrrGrrrrrrrrGr	8 9	(D1,D5)
5.00	5.00	12.00	rrrrrgGGGGrrrrrrrrrr	3	(D2,D5)
5.00	5.00	12.00	rrrrrrrrrrrrrrrgGGGG	3	(D1,D6)
5.00	5.00	39.00	rrrrrgGGgGrrrrrgGGgG	10	(D2,D6)
5.00	5.00	13.00	rrrGGGrrrrrrrGGGrrrr	11 12	(D3,D7)
5.00	5.00	13.00	gGGGGGrrrrrrrrrrrrrr	13	(D4,D7)
5.00	5.00	15.00	rrrrrrrrrrrgGGGrrrrr	14	(D3,D8)
5.00	5.00	24.00	gGGrrrrrrrrgGrrrrrrr	15	(D4,D8)
3.00			rrrrrrrrrGrrrrrrrryr	1	(D1,D5)-(D2,D5)-Y
3.00			rrrrrrrrryrrrrrrrrGr	2	(D1,D5)-(D1,D6)-Y
4.00			rrrrrgyyyyrrrrrgyyyy	4	(D2,D6)-(D3,D7)-Y
3.00			rrrGGGrrrrrrryyyrrrr	5	(D3,D7)-(D4,D7)-Y
3.00			rrryyyrrrrrrrGGGrrrr	6	(D3,D7)-(D3,D8)-Y
3.00			gGGyyyrrrrrrrrrrrrrr	7	(D4,D7)-(D4,D8)-Y
4.00			rrrrrrrrrrrgGyyyrrrr	7	(D3,D8)-(D4,D8)-Y
4.00			yyyrrrrrrrryyyrrrrrr	16	(D4,D8)-(D1,D5)-Y
2.00			rrrrrrrrrrrrrrrrrrrr	0	(D4,D8)-(D1,D5)-R

Figure 5: Signalized intersection: turning movements and signal timing.

2.5.3 Turning Configuration

Turning configuration is a critical step in ensuring accurate vehicle movement patterns within the SUMO simulation. Using the extracted link and lane data, turning volumes for each movement are identified at the edge and lane levels. This information is used to generate the flow.xml file, which defines the volume and direction of traffic flows across the network. The flow.xml, together with the previously generated net.xml, is then used as input for SUMO's *jtrrouter* tool to create the rou.xml file. The rou.xml file contains route definitions that translate turning movements into simulated vehicle paths across the network. To ensure that the turning flows from Synchro are correctly represented in SUMO, several constraints are applied during route generation. One important constraint is the prohibition of loop routes, which can otherwise result in vehicles exiting and re-entering the network through dead-end edges. Additionally, U-turns are invalidated unless explicitly defined in the original Synchro data, as SUMO may otherwise automatically generate U-turn connections that distort turning volume accuracy (Figure). These adjustments help maintain consistency between Synchro's planned traffic flows and SUMO's simulation behavior, enabling reliable and realistic traffic modeling.

2.5.4 SUMO Configuration

Once the SUMO network file (net.xml) is generated, simulation parameters such as start time and duration are extracted from the UTDF file to create the SUMO configuration file (.sumocfg). This file plays a central role in defining how the microsimulation will be executed. It specifies essential simulation inputs, including the network, route, and signal files, as well as simulation time settings. Additionally, the configuration file allows users to configure various output options for detailed analysis, such as vehicle emissions, floating car data, loop detector readings, lane-changing behavior, and car-following behavior. These outputs provide valuable insights into network performance and traffic behavior under different conditions. The configuration file thus serves as the control hub for simulation execution, ensuring all components are correctly integrated and tailored to meet specific analysis goals.

3. CASE STUDY

3.1 Study Area

This study selects the city of Tempe, AZ, as the study area. As depicted in Figure , the network includes 755 intersections extracted from the UTDF file, of which 227 are signalized. The network's scale and complexity present significant challenges for integration from Synchro to SUMO. Moreover, the level of signal protection varies widely across the network, incorporating elements such as pedestrian phases, protected left or right turns, and multiple signals timing strategies, including fixed time, actuated, and adaptive control. This heterogeneity increases the complexity of accurately representing signal behavior and vehicle movements in the simulation. Each unique intersection and control type must be carefully accounted for, making the integration process both technically demanding and critical for achieving realistic and reliable microsimulation outcomes.

Figure 6: Network for Tempe, AZ, shown in OpenStreetMap, synchro network, and SUMO network.

3.2 Automation in Key Features Calculation and Visualization

Key features are extracted and calculated and then visualized for each signalized intersection. Figure 4 and Figure 7 illustrate the outputs generated by Sigma-X for the selected intersection at Scottsdale Road and Curry Road in Tempe, AZ. Figure 4 provides an overview of the intersection layout, including speed limits and lane configurations. The eastbound and westbound directions have speed limits of 40 mph, while the northbound and southbound approaches are set at 40 mph and 60 mph. Each approach contains five lanes, with typical configurations of two left-turn lanes, two through lanes, and one right-turn lane on EB and WB. Two left-turn lanes and three through lanes (shared right lane) for NB and SB. Movement volumes vary significantly by movement. For example, the northbound approach records 1,082 through vehicles per hour, while the eastbound right-turn movement sees 139 vehicles per hour. Figure 7 details the signal phasing, showing a total cycle length of 110 seconds and the specific green, yellow, and red durations for each phase, and visualizes additional key metrics such as turning volumes (in vehicles per hour), number of lanes, volume-to-capacity (V/C) ratios, movement capacities, control delays, and split durations.

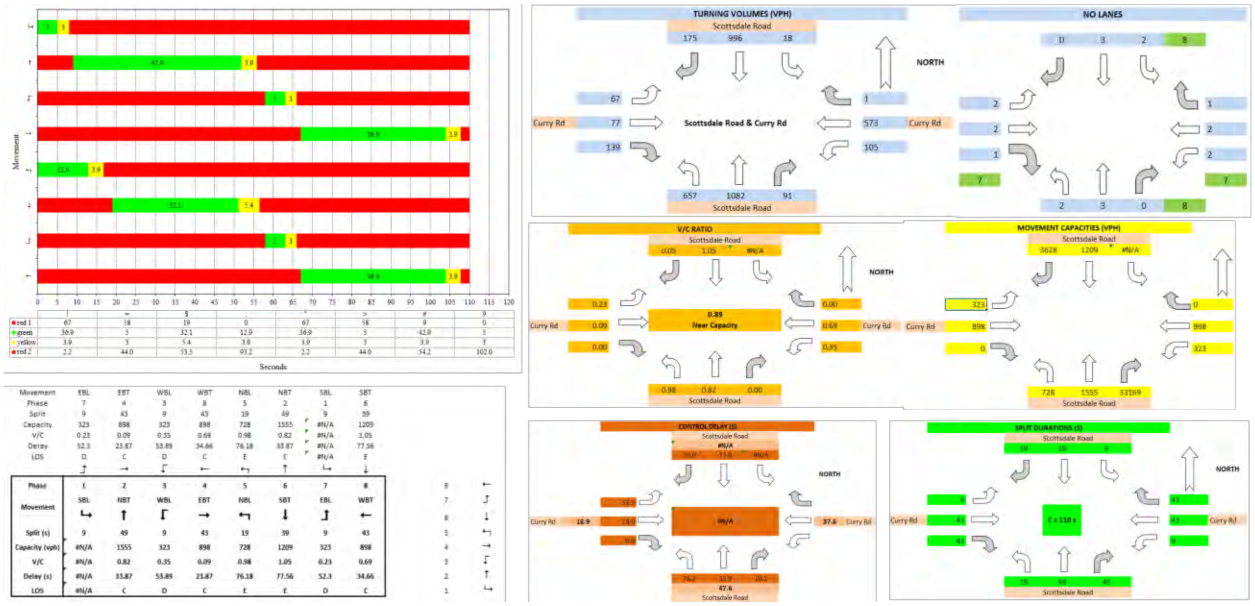


Figure 7: Illustration of intersection performance and signal phasing and timing.

3.3 Automation in SUMO Microsimulation

The automation framework enables seamless conversion of the original UTDF-based network into GMNS and SUMO formats, as illustrated in Figure . Once validated, the converted network is used to perform large-scale traffic microsimulation in SUMO. This automated process not only generates the necessary network and routing files but also configures a wide range of simulation outputs for comprehensive analysis. Output files include vehicle emissions, individual vehicle trajectories, floating car data, loop detector readings, queuing behavior over time, collision events, and fundamental traffic flow diagrams. These data sources collectively support detailed evaluation of traffic performance, environmental impact, and safety conditions across the network. The integration of automated output generation streamlines the microsimulation workflow and enables consistent, repeatable analysis across different scenarios. By eliminating manual steps and ensuring proper alignment between Synchro, GMNS, and SUMO, the system provides a robust foundation for high-fidelity, data-driven transportation modeling and decision support.

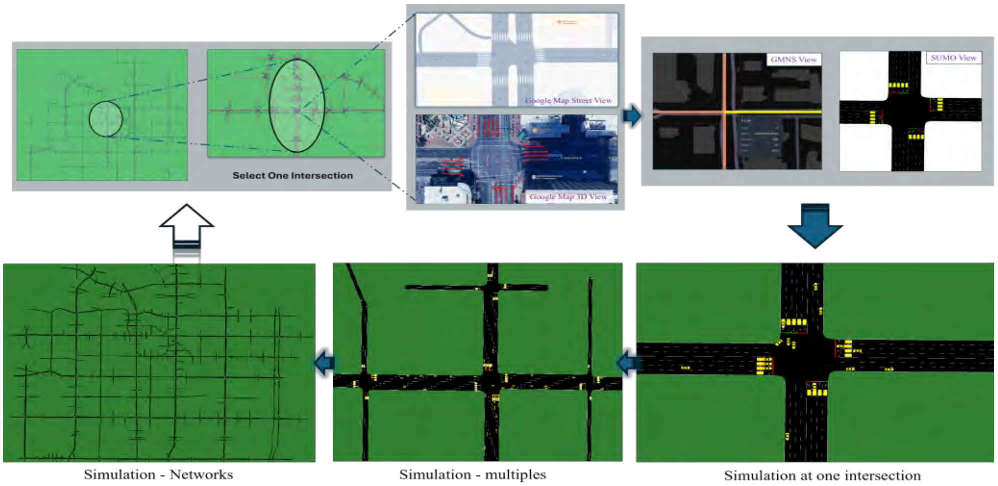


Figure 8: Automation in network simulation in SUMO.

4. CONCLUSION AND FUTURE WORK

In this paper, we explored an automatic process of network coordinating, traffic signal integration, and traffic flow conversion from Synchro to SUMO, identifying both the feasibility and challenges involved. Our approach began with a comparative analysis of traffic network features, data formats, and signal timing schemas between the two platforms. Key challenges in converting Synchro UTDF data into microsimulation-ready networks focused on signal integration, spatial conversion, and turning flow accuracy. Signal conversion remains a critical bottleneck, requiring precise alignment of phasing, timing, and coordination data to ensure reliable simulation outcomes. Network conversion also presents difficulties, particularly in translating Synchro's relative coordinate system into georeferenced formats compatible with GIS tools. Additionally, accurately transforming turning movement data is essential for modeling realistic intersection behavior but often involves tedious manual preprocessing.

While previous efforts have made progress in isolated aspects of the conversion process, none offer a fully automated and scalable end-to-end solution. To fill this gap, we introduce utdf2gmns, an open-source Python tool designed to automate the transformation of Synchro UTDF files into GMNS-compliant networks for SUMO simulation. The tool supports automatic geocoding, integration with the Sigma-X engine for intersection analysis, robust SUMO network generation, and extendibility to other microsimulation platforms. Future work will focus on expanding support for adaptive signal systems, incorporating real-time data inputs, and enhancing interoperability with additional simulation frameworks to promote reproducibility and collaborative research in traffic modeling.

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