Paving the Way: Innovative Data Collection Methods for Sidewalk (or Pedestrian) Infrastructure

ITS4US Deployment Program Webinar

October 24, 2024

Source: iStock

Webinar Agenda

Purpose of this Webinar

- This session will explore innovative methods for collecting and digitizing sidewalk data, aimed at enhancing pedestrian safety, mobility and access.

Agenda

- ITS4US Program Overview (Elina Zlotchenko)
- Safe Trips in a Connected Transportation Network (ST-CTN) (Randy Guensler)
- Transportation Data Equity Initiative (Anat Caspi)
- Moderated Question and Answer with the Speakers

Webinar Protocol

- You are encouraged to ask questions via Q&A chatbox. Questions will be added to the queue by moderators. No need to re-submit if you haven't seen it.
- The webinar recording and the presentation material will be posted on the ITS4US website within the next 2 weeks.

Elina Zlotchenko

Program Manager, ITS4US

U.S. Department of Transportation

Intelligent Transportation Systems (ITS) Joint Program Office (JPO)

ITS4US Program Overview

- A USDOT Multimodal Deployment effort, led by ITS JPO and supported by OST, FHWA and FTA
- Supports multiple large-scale replicable deployments to address the challenges of planning and executing all segments of a complete trip

ITS4US
IT'S TRANSPORTATION FOR ALL OF US

Vision: Innovative and integrated complete trip deployments to support seamless travel for all users across all modes, regardless of location, income, or disability

ITS4US Deployment Program

ITS4US

Heart of Iowa Regional Transit Agency (HIRTA) – Dallas County, IA

Integrated health appointment and mobility service system

Georgia Department of Transportation (GDOT) – Gwinnett County, GA

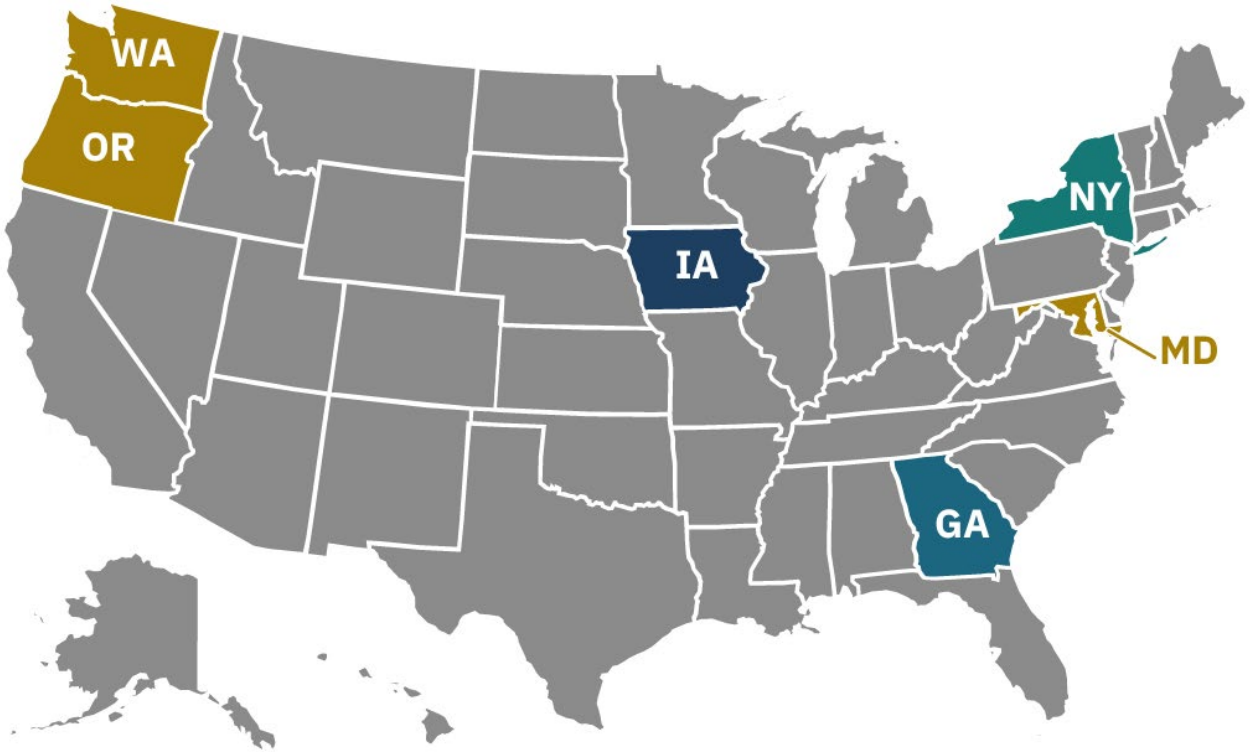
Safe trips in a connected transportation network

University of Washington (UW) – OR, WA, MD

Data and software promoting equitable travel opportunities

Niagara Frontier Transportation Authority (NFTA) – Buffalo, NY

Personalized, multi-modal trip planning, on-demand transportation and wayfinding



Source: USDOT

Randall Guensler, PhD

ITS4US ST-CTN Pedestrian Impedance Lead

Associate Director, NCST

Professor, School of Civil and Environmental Engineering at Georgia Institute of Technology

Safe Trips in a Connected Transportation Network (ST-CTN)

- Gwinnett County, GA
- Key Technologies:
  - Connected Vehicle Messaging
  - Transit Signal Priority
  - Machine Learning
  - Predictive Analytics
  - Mobile Application (G-MAP)

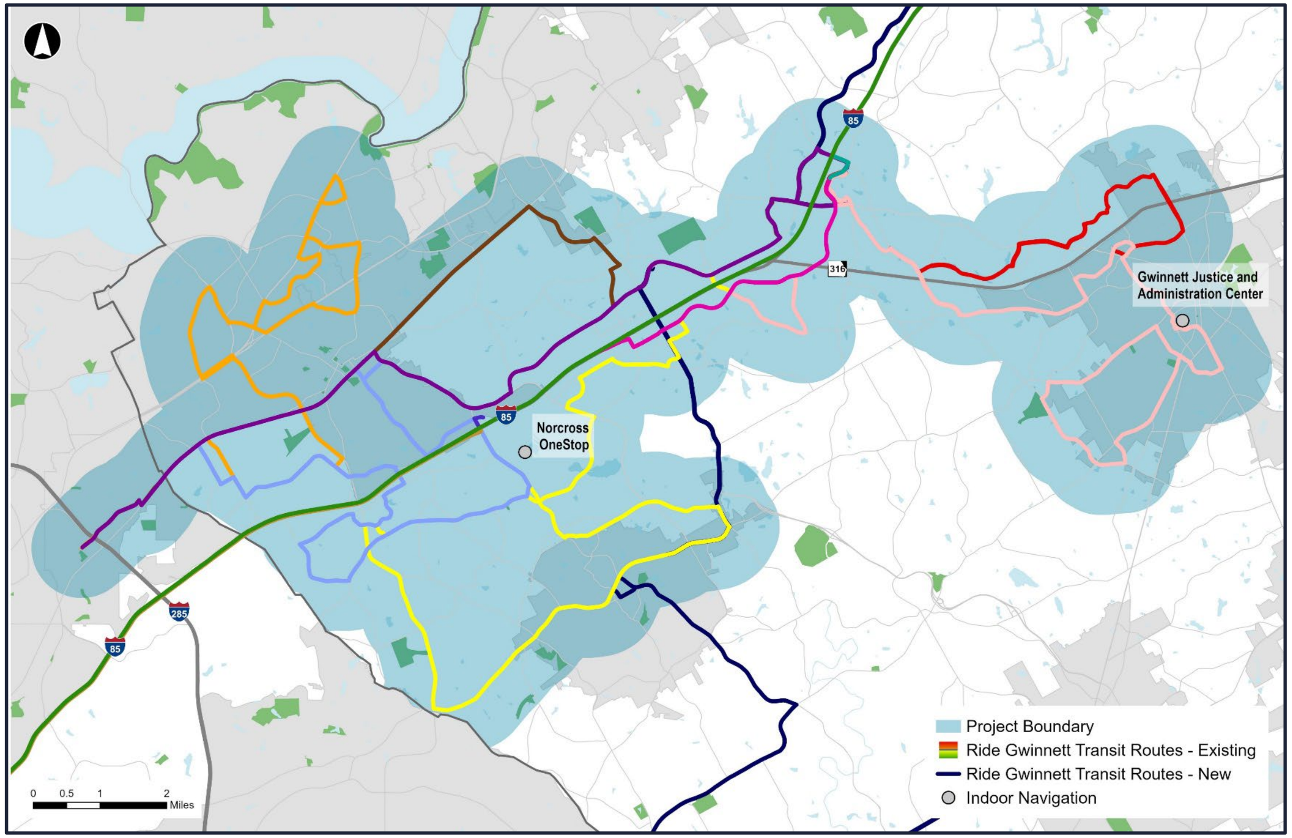

Source: iStock

Deployment Concept - Goals

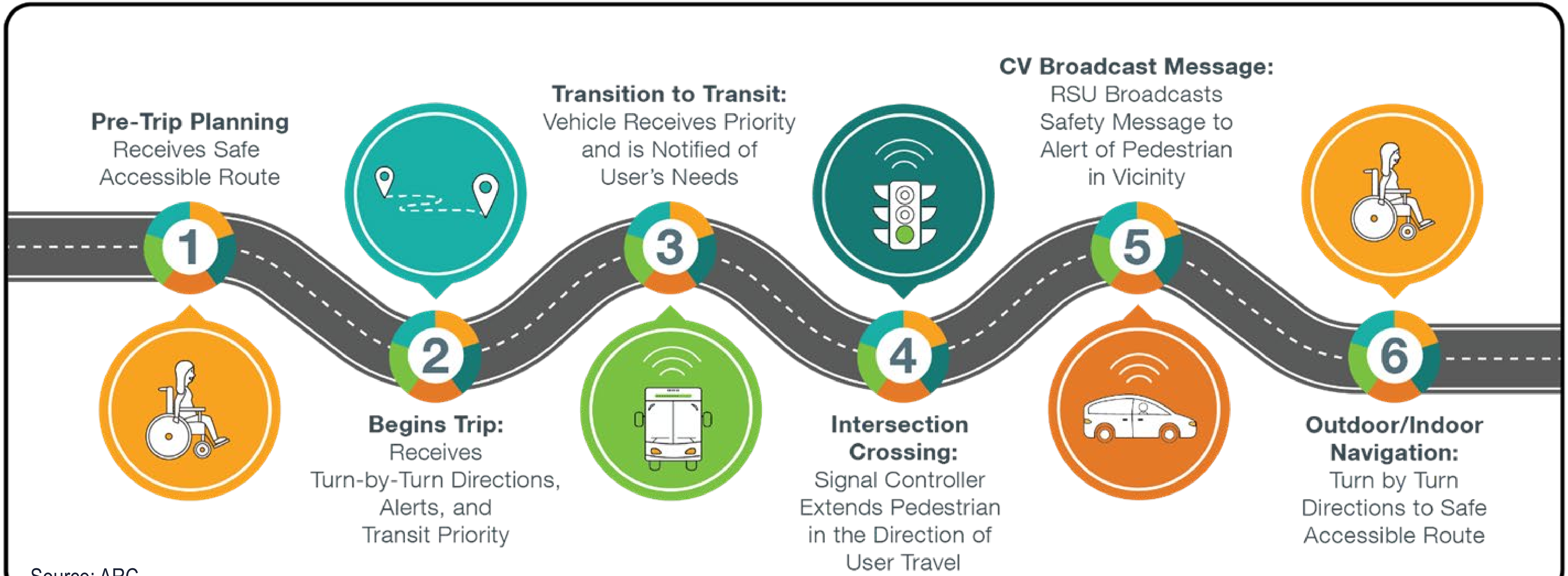
- **Goal 1:** Enhance multimodal complete trip experience with the ST-CTN system functions and features, particularly for underserved communities.
- **Goal 2:** Enhance safety for ST-CTN system users, particularly for underserved communities.
- **Goal 3:** Improve reliability for system users, particularly for underserved communities.
- **Goal 4:** Improve mobility and accessibility for system users, particularly for underserved communities.

ITS4US Study Area: Gwinnett County, GA

- Richly diverse area
- Major transit hubs
- 220 miles of sidewalk connect transit stops
- Includes Lawrenceville and suburban land use
- Wide and high-speed roadways
- Inconsistent pedestrian infrastructure



Georgia Mobility and Accessibility Planner (G-MAP)



Source: ARC

Navigation Provided by Mobility Mode Best Routes - Likely on Different Paths

Eight Primary Categories

- Person walking who has no mobility limitations
- Person walking who has minor mobility limitations
- Person walking with a mobility device (cane, walker, etc.) or pushing a stroller
- Person using a standard manual wheelchair
- Person using an electric wheelchair
- Person using a mobility scooter
- Person walking with some low vision limitations
- Person walking who is blind or has major vision limitations

Link travel time impedance + event impedance (by mode)

Event Impedance

Link feature impedance

Link is missing (width = 0)

Link defect impedance

Link completely blocked

Crossing link impedance

Associated ramp is missing (width=0)

Impedance is so large that a wheelchair user needs to divert across the street at a prior road crossing

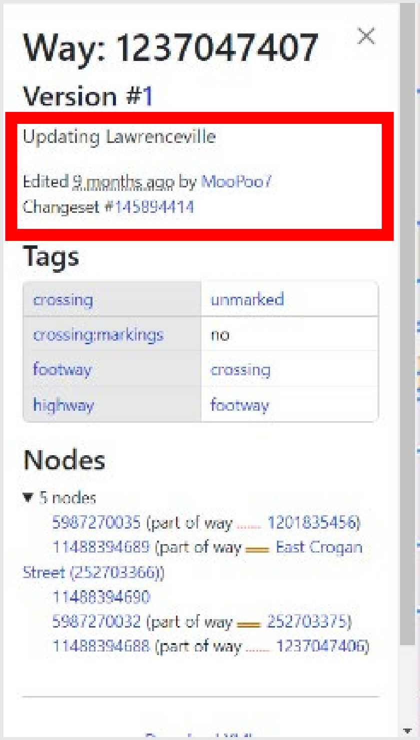
Pedestrian Network Development Goals

- G-MAP requires a navigable pedestrian network
  - Completely independent of the roadway network
  - Assign impedance to each pedestrian link for routing
  - Apply impedance at the logical link level, where pedestrians can change direction (network nodes)
- Previous GT networks were derived from parcel-level land use data and roadway centerlines
- OSM was selected for G-MAP pedestrian network preparation
  - OSM contains some sidewalks (about 30% in our study area)
  - OSM network structure is used in OTP-based routing apps

Network Development Protocols

- Developed OSM network coding protocols
  - Disaggregate existing OSM pedestrian network
  - Add links to create a comprehensive, routable pedestrian network
- Path assessment
  - Identified private vs. public sidewalk
  - Removed potentially unsafe path links and dead-ends
- Identify final navigation network
  - Reconcile with AWS Neptune

Example of a Problem Crossing Added to the Demo Zone by the Public



- Unsafe ‘Unmarked Crossing’ link puts a wheelchair user into a high-speed right-turn intersection, with no protection barriers nor curb cuts to egress

Pedestrian Infrastructure Data Collection

- Vehicle-based video
  - Asset identification
  - Drive entire study area
- Wheelchair-based video
  - Pedestrian assets manually inspected in the demo zone
  - 52 data collectors

Vehicle Video Collection is Inexpensive

GoPro Cameras (3)

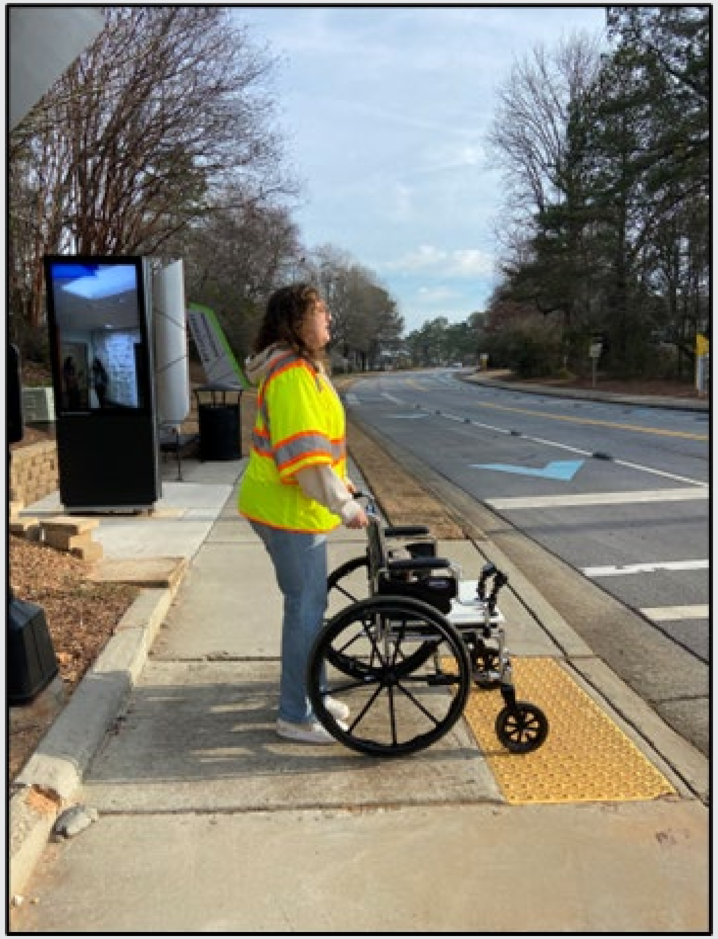
Stereo-optical Camera

GoPro Cameras (3)

Vehicle Flythrough Data Collection

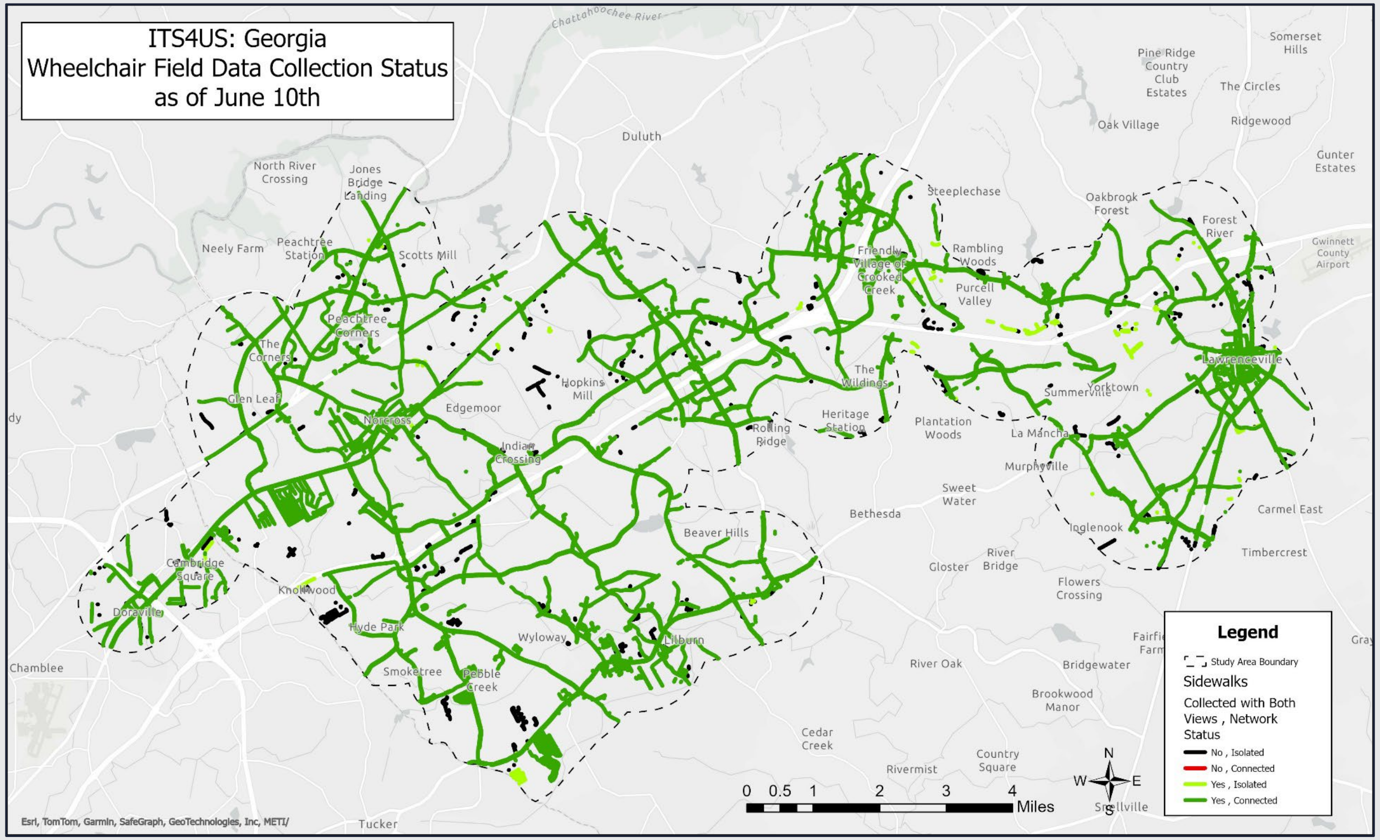
- GoPro camera passenger side video (plus driver side and front view)
- Manual flythrough for presence/absence
- Machine vision flythrough

Wheelchair Video Data Collection Walking Speed (2-3 miles/hour)



ITS4US Study Area

- Study area
- 446 miles of sidewalks (10,896 sidewalk links)
- 3,148 road crossings (41 miles of crossings)
- 4,041 pedestrian ramps
- 17,235 vehicle curb cuts



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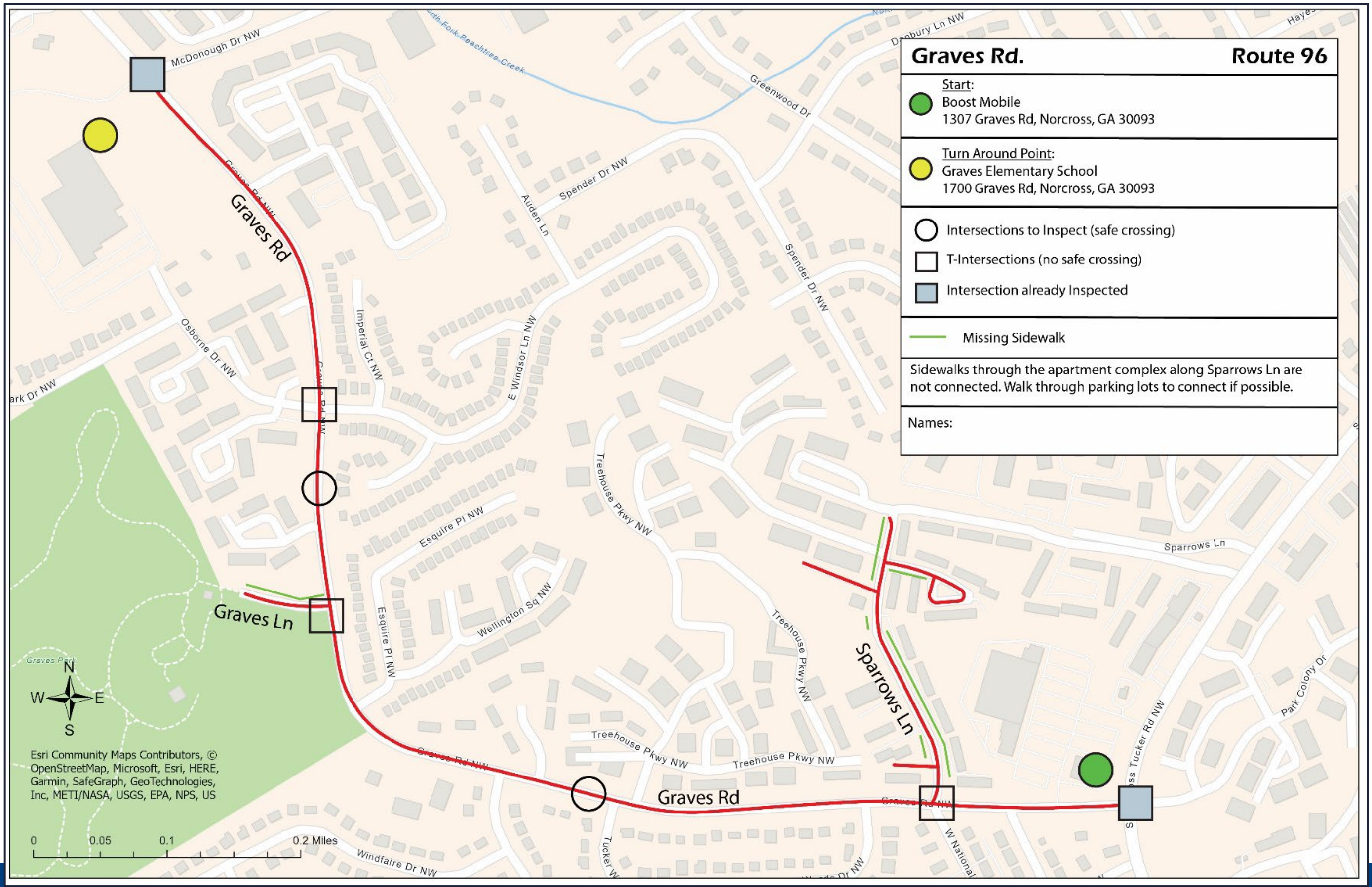
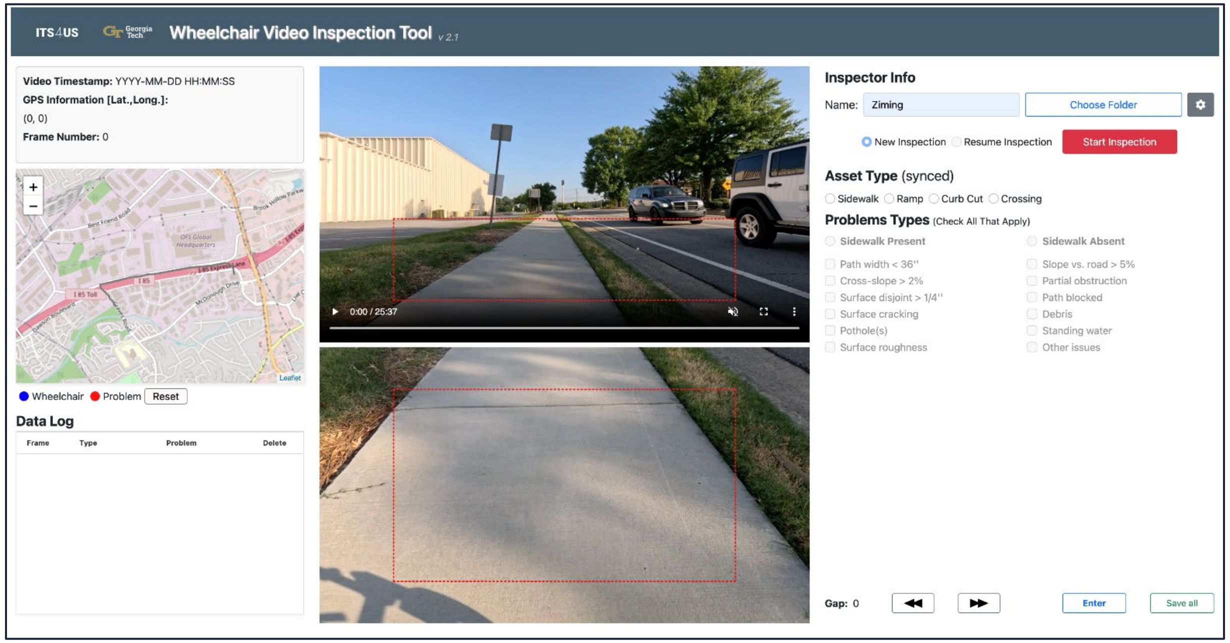
Wheelchair Video Archives



- Video provides an archive of asset design and condition
- Videos are used in online inspection procedures
- Engineers and planners can always refer back to the video to assess conditions

Video Inspections for Asset Defects
Sidewalks, Curb Ramps, Curb Cuts, Crosswalks

- Remote video inspection
  - Map location panel
  - Rolling video images
  - Inspection inputs
- Click image to stop video and record defect data
- Inspectors can identify 90% of design/ condition issues
  - Surface defects, cross-slope issues, changes in surface height >1/4”, obstructions, width narrowing, debris, etc.



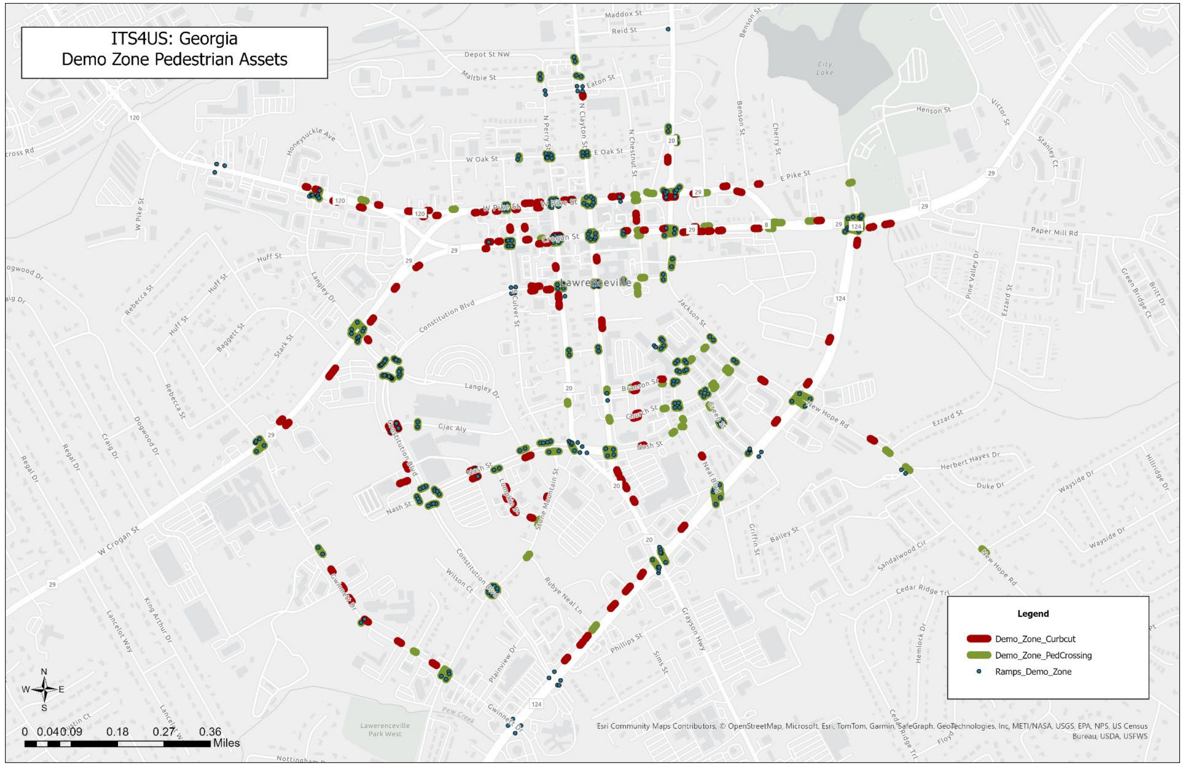
Supported browsers include Chrome®, Edge®, and Firefox®

Source: Georgia Tech Data Collection Team 2023-2024

Wheelchair Camera Views
Time-Aligned Video Inspection

- Forward view allows the user to identify features and condition
- Downward view supports assessment of surface condition

Asset Map for the Demo Zone



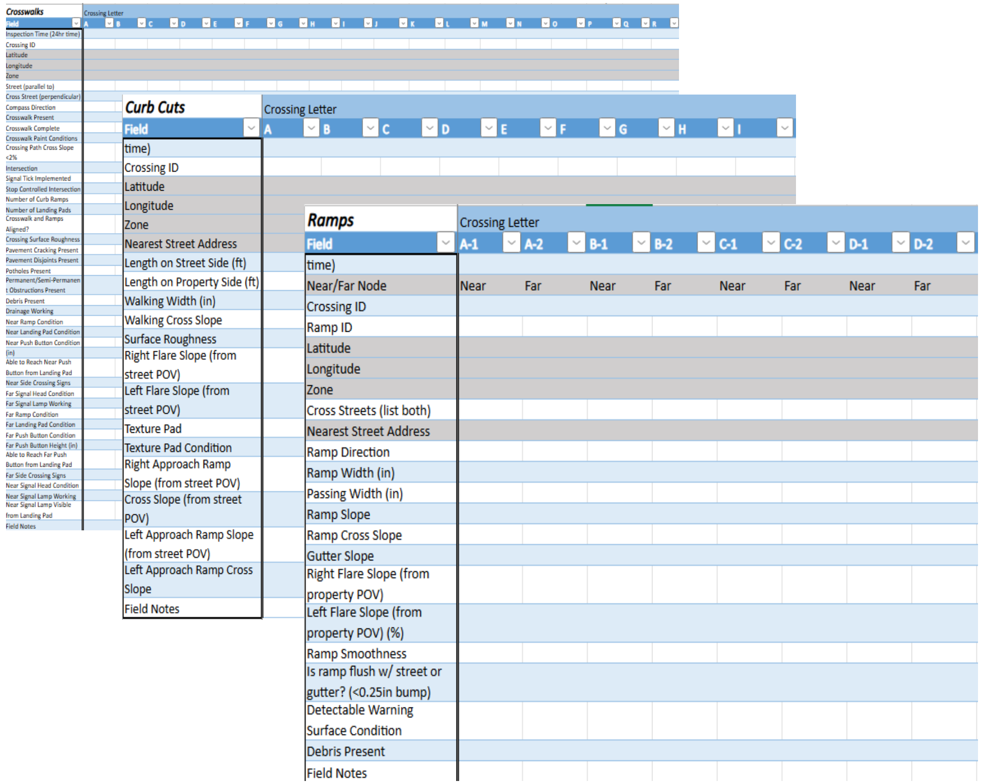
Demo Zone Pedestrian Assets

Manual Field Inspections

- Pedestrian assets inspected:
  - Sidewalks and pedestrian crossings
  - Pedestrian curb cuts (pedestrian ramps)
  - Vehicle curb cuts (driveway crossings)
- Intersection inspections (clockwise, typically four crossings)
  - Conducted in the City of Lawrenceville (demonstration zone)
  - Assess infrastructure vs. ADA design and condition
    - Signs, push buttons, signal heads, etc.
- Data are manually collected on an electronic inspection form
  - Tablet based data entry (phones also work)

Tablet Excel Forms for Manual Inspections
Curb Ramps, Curb Cuts, Crossings

- Separate tablet data entry forms for:
  - Pedestrian road crossings
  - Pedestrian curb cuts (ramps)
  - Vehicle curb cuts (driveways)
- Each sheet contains relevant fields for each asset and sub-type
  - 10 curb ramp types
  - 4 vehicle curb cut types
- Manual data entry
  - Fresh forms for each route
  - Standardized naming conventions
- Uploaded to database after each trip



Summary of ITS4US GDOT/ARC Outputs

- Asset inventory (links, ramps, curb cuts, crossings, etc.)
- Pedestrian network for OTP navigation
  - Disaggregated OSM to logical links and completed network
  - Screened private and inaccessible links from navigation paths
- Inspected assets for design and condition (data structure)
- Assign time + event impedance to logical links
  - Crossing with no ramp is penalized for wheelchair mode
- Calculate and provides lowest impedance path via G-MAP for each mobility mode
- Everything is open architecture with open source software
  - Tech transfer documentation is forthcoming

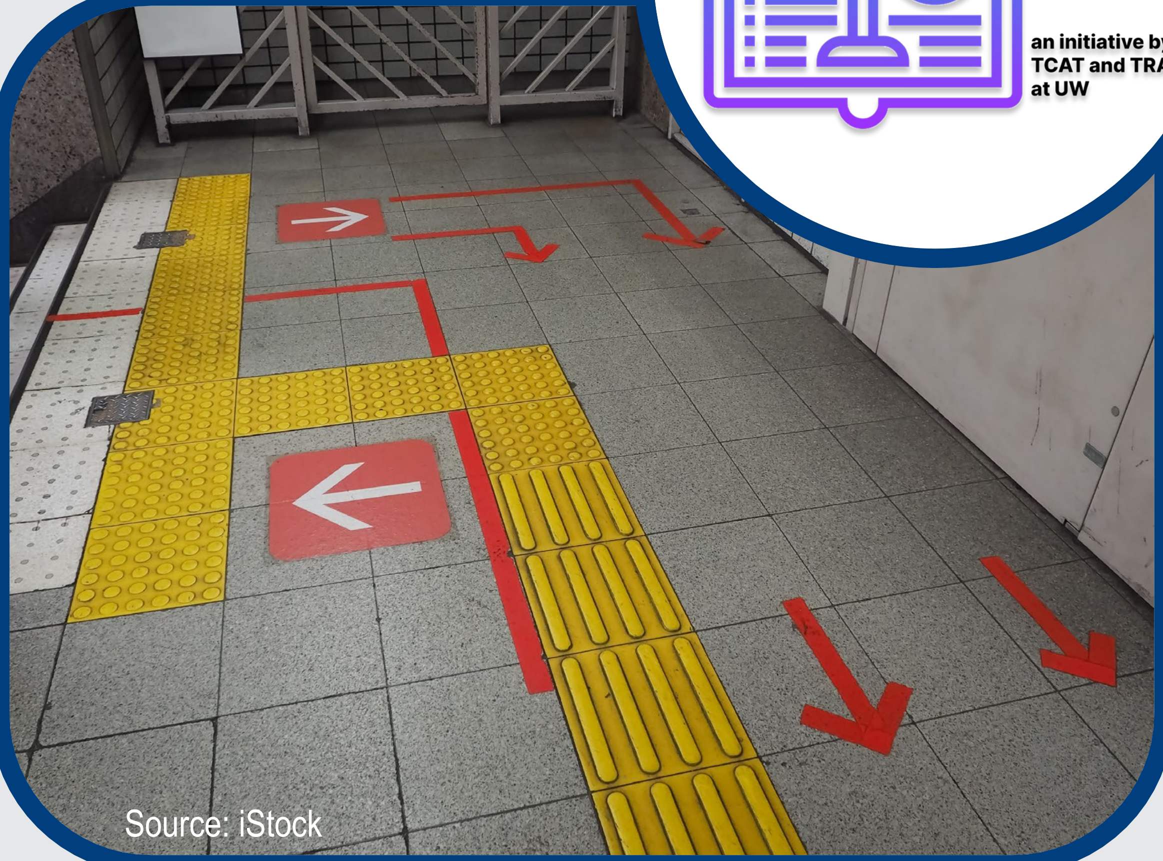
Anat Caspi, PhD

Director, Taskar Center for Accessible Technology

Paul G. Allen School of Computer Science & Engineering, University of Washington

Transportation Data Equity Initiative

- King & Snohomish County, WA
- Multnomah & Colombia County, OR
- Harford & Baltimore County, MD
- Key Technologies:
  - Data Standards (OpenSidewalks, GTFS-Flex, GTFS-Pathways)
  - Open-Source Data Collection
  - Data Sharing System



Source: iStock

Transportation Data Equity

an initiative by TCAT and TRAC at UW

OpenSidewalks mapping with Oasis: Predicting Pedestrian Path Accessibility from Street-Level Video (click link to access video)

UW Taskar Center's: Applied AI methods for Accessibility-first Pedestrian Mapping

- uwtcat@uw.edu

JOIN US FOR OPEN THE PATHS-
Our 8th annual conference on data-driven accessibilty-first transportation systems
March 27-28, 2025
TinyURL.com/TCATSignup.

The Taskar Center for Accessible Technology

Designing for the fullness of human experience

https://tcat.cs.washington.edu/

The Taskar Center for Accessible Technology (TCAT) at the Paul G. Allen School for Computer Science & Engineering **develops translates and deploys technologies that increase independence and improve quality of life for People with Disabilities.**

Transportation Data Equity
an initiative by TCAT & UW TRAC

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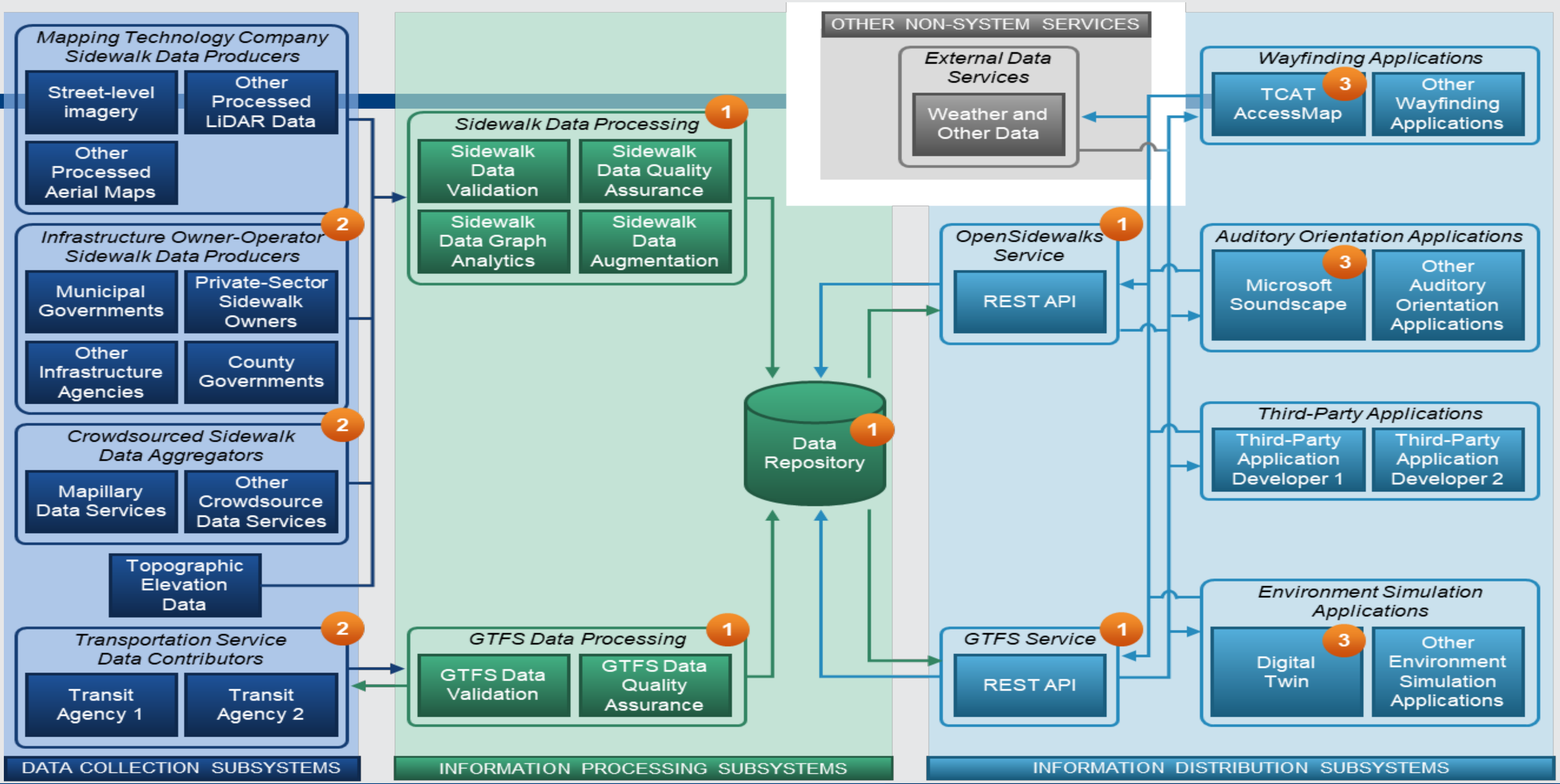
Applied AI for Accessibility-First Transportation Data

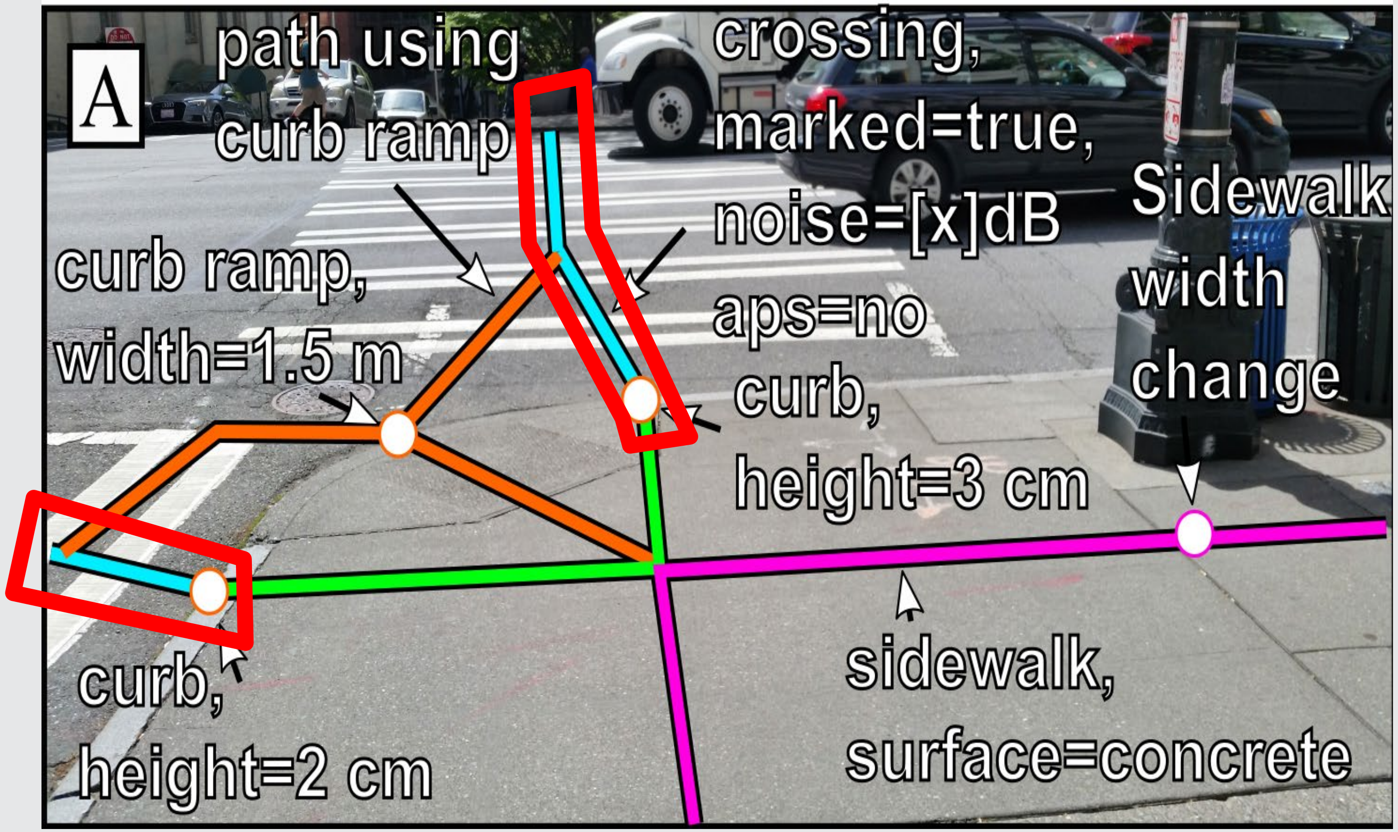
Transportation Data Equity
an initiative by TCAT & UW TRAC

Applied AI in Context of TDEI System



1 Components UW Team will develop and test
2 UW will develop toolsets to support data collection
3 Software applications that demonstrate data pipelines

Accessibility-first Pedestrian Path Data: OpenSidewalks Data Schema

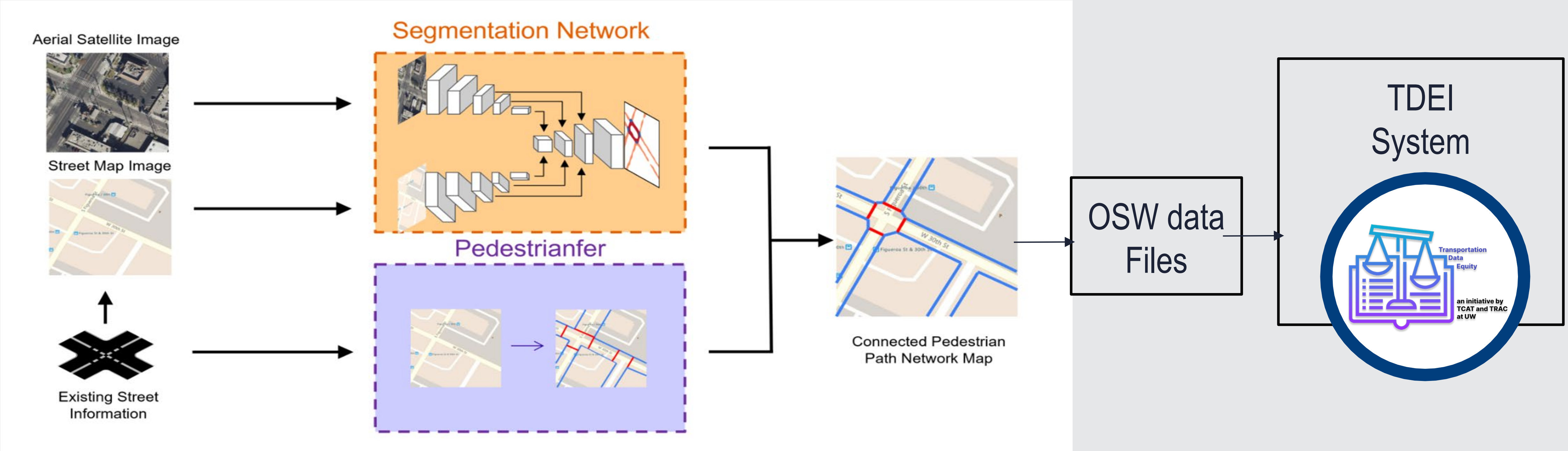


OpenSidewalks.com

Github.com/OpenSidewalks/OpenSidewalks-Schema: Repository for the draft proposal of the OpenSidewalks schema (github.com)

N. Bolten et al., "A pedestrian-centered data approach for equitable access to urban infrastructure environments," 2017
tinyurl.com/2017OpenSidewalks

Prophet: An end-to-end system to infer a connected pedestrian path network



Prophet- the Pedestrian Path Network Graph Inference Method outputs OpenSidewalks data at scale

Yuxiang Zhang, Bill Howe, Anat Caspi. "Reliable, Routable, and Reproducible: Collection of Pedestrian Pathways at Statewide Scale ". The 104th Transportation Research Board (TRB) Annual Meeting (2025).
https://tinyurl.com/2024PathwayBench

Prophet Compared to Satellite Imagery Segmentation Methods

Method	Area	Global			Local		Local (relative to Ground Truth)	
		# nodes	# edges	avg degree	avg CC	avg BC	edge-retrieval F1	*TraversabilitySimilarity*
Ground Truth	Washington, D.C.	19245	21462	2.23	1.62	0.14	1.0	1.0
	Portland, OR	937	1134	2.42	1.45	0.13	1.0	1.0
	Seattle, WA	9386	10402	2.22	1.65	0.13	1.0	1.0
Pedestrianfer	Washington, D.C.	27651	24948	1.80	6.44	0.02	0.84	0.37
	Portland, OR	1615	1376	1.70	6.46	0.02	0.89	0.30
	Seattle, WA	10002	8871	1.77	5.43	0.03	**0.93**	0.38
Tile2net	Washington, D.C.	48153	46369	1.93	5.77	0.03	0.84	0.35
	Portland, OR	937	844	1.80	2.77	0.04	0.76	0.04
	Seattle, WA	12617	11732	1.86	5.01	0.03	0.90	0.17
Prophet(VGG-16)	Washington, D.C.	8908	10397	2.33	1.15	0.13	0.84	0.38
	Portland, OR	945	1056	2.23	**1.39**	0.13	0.90	0.47
	Seattle, WA	5061	5497	2.17	1.37	0.13	0.89	0.41
Prophet (DeepLabv3)	Washington, D.C.	9967	11503	2.22	1.12	0.13	0.87	0.39
	Portland, OR	1138	1267	2.25	1.71	0.14	0.87	0.48
	Seattle, WA	5472	6046	2.21	1.35	0.14	0.89	0.42
Prophet (ViT)	Washington, D.C.	10347	11608	**2.22**	**1.20**	**0.13**	**0.88**	**0.39**
	Portland, OR	1121	1205	**2.26**	1.68	**0.13**	**0.91**	**0.48**
	Seattle, WA	5516	6247	**2.22**	**1.39**	**0.13**	0.90	**0.43**

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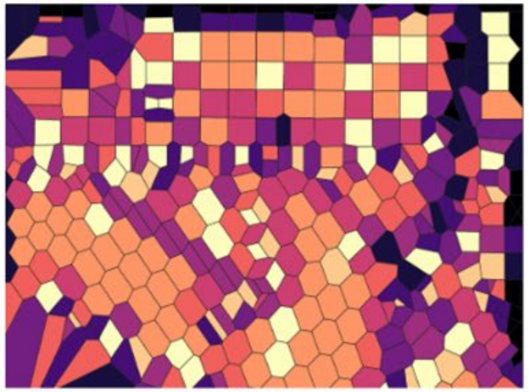
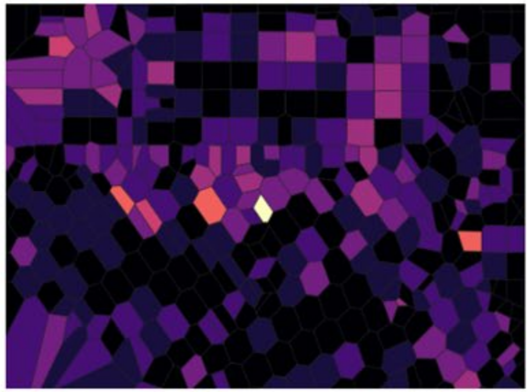
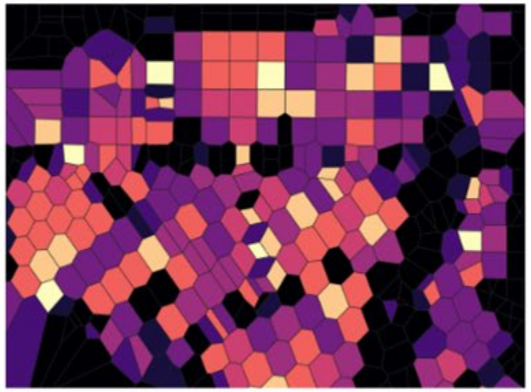
PathwayBench: Assessing Routability of Pedestrian Pathway Networks Inferred from Multi-City Imagery (arxiv.org)



(a) GT, *Traversability=0.30*



(b) Tile2Net, *Traversability=0.05*



(c) Prophet, *Traversability=0.15*

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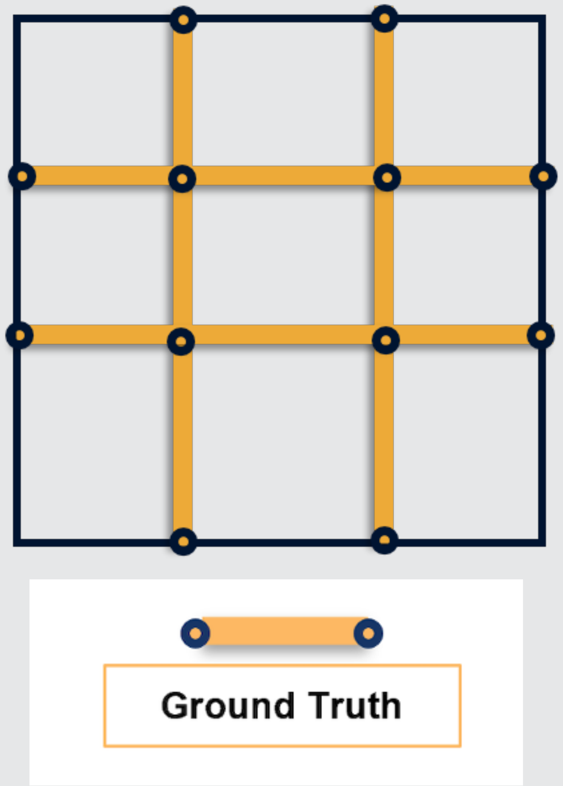
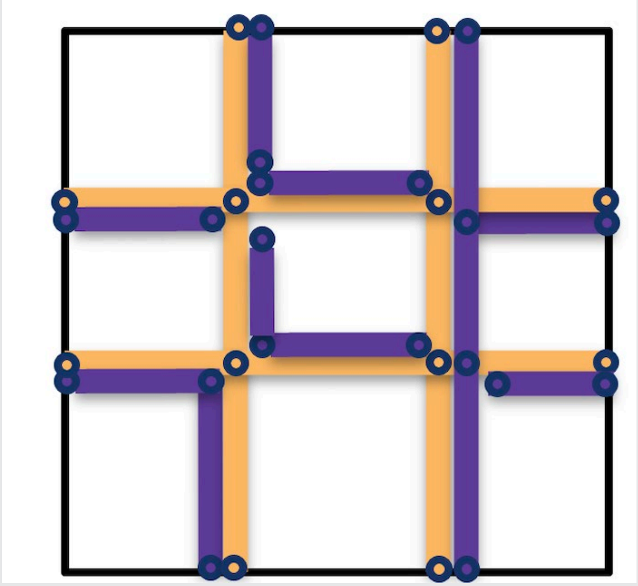
Traversability: Pedestrian Graph Evaluation must compare ROUTES not edges or nodes



Perfect precision and recall for *edges*
Poor precision and recall of *routes*



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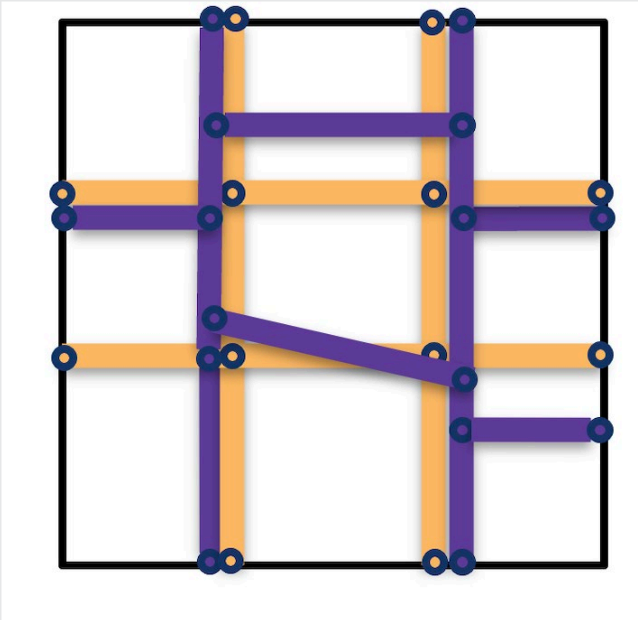
Good precision and recall of *routes*



Typical metrics count edges and ignore connectivity

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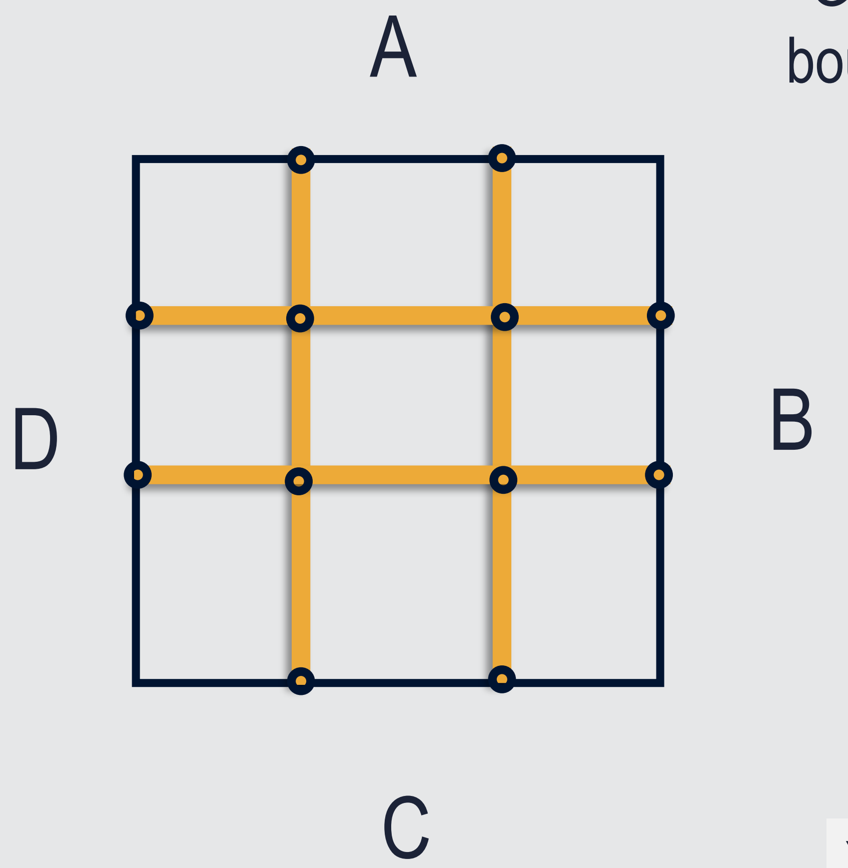
Traversability: Intersection Traversability Is an Atomic Representation of Shift-invariant connectivity (1)



Ground truth boundary-to-boundary traversable routes

A ↔ B

A ↔ C

A ↔ D

B ↔ C

B ↔ D

C ↔ D

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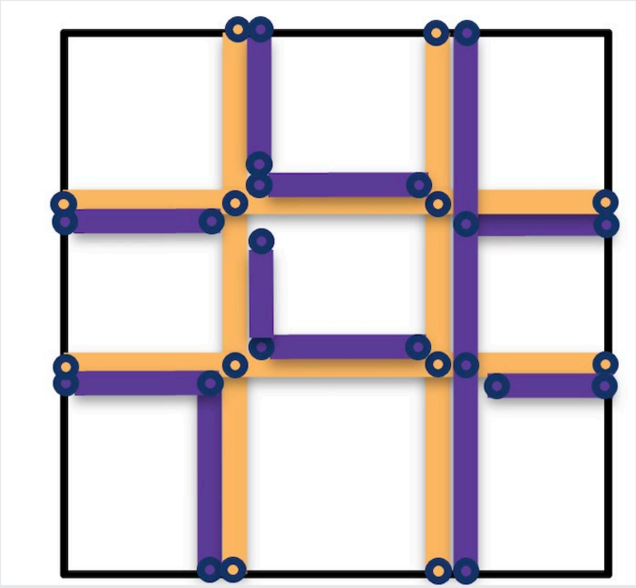
Traversability: Intersection Traversability Is an Atomic Representation of Shift-invariant connectivity (2)

A

D  B

C

Ground truth boundary-to-boundary traversable routes

~~A ↔ B~~

A ↔ C

~~A ↔ D~~

B ↔ C

~~B ↔ D~~

C ↔ D

3/6 routes traversable

Perfect precision and recall of edges

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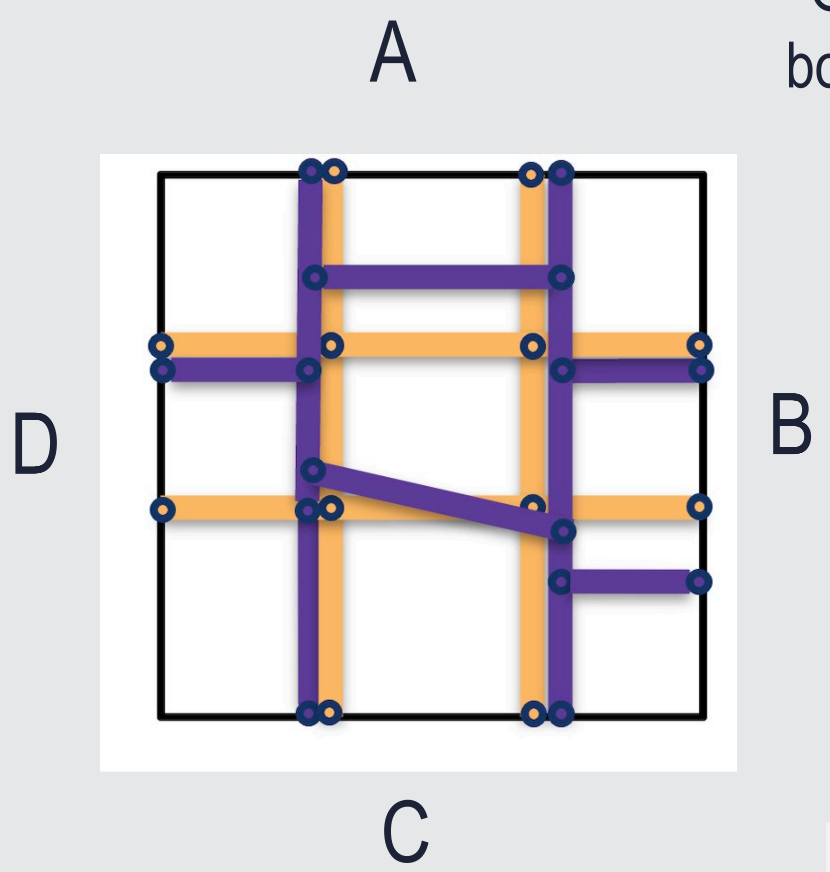

Ground truth boundary-to-boundary traversable routes

A ↔ B
A ↔ C
A ↔ D
B ↔ C
B ↔ D
C ↔ D

All 6/6 routes traversable

Some missing and misplaced edges

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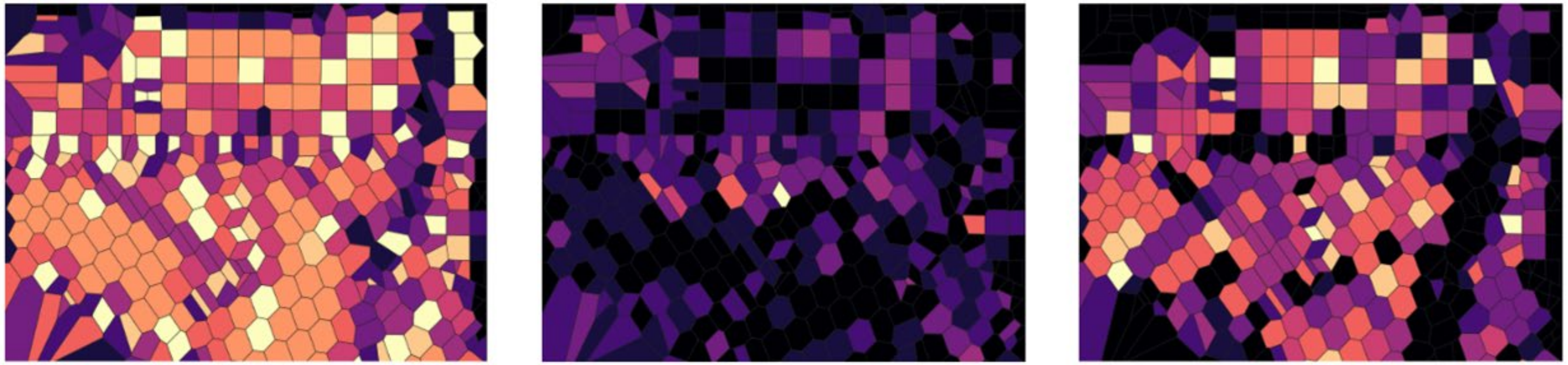

(a) GT, *Traversability=0.30* (b) Tile2Net, *Traversability=0.05* (c) Prophet, *Traversability=0.15*

https://tinyurl.com/2024PathwayBench

Prophet data: 4 U.S. Counties + 39 Counties in WA State

(a) King County, WA (b) Snohomish County, WA (c) Multnomah County, OR (d) Columbia County, OR (e) Harford County, MD (f) Baltimore County, MD

Area	Number of sidewals	length of sidewalks (m)	Number of crossings	length of sidewalks (m)	Number of intersections
King	249683	15850008	133603	1968246	45971
Snohomish	62991	5033712	33483	480327	12388
Multnomah	178631	10647695	92788	1385683	31697
Columbia	17762	2253858	9291	139957	3231
Harford	60979	5141570	32224	460859	11110
Baltimore	159842	11379123	84479	1215692	28432

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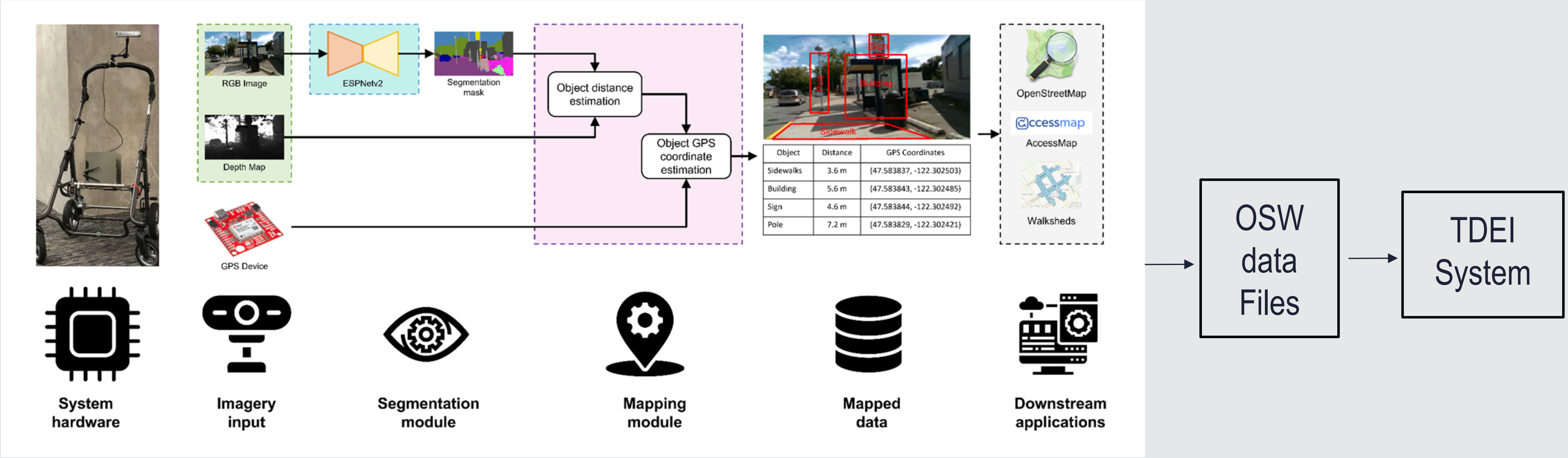
OASIS: An on-device automated sidewalk mapping and assessment system



Yuxiang Zhang, Suresh Devalapalli, Sachin Mehta, Anat Caspi. "OASIS: Automated Assessment of Urban Pedestrian Paths at Scale". The 103rd Transportation Research Board (TRB) Annual Meeting (2024)

Tinyurl.com/2023OasisSystem

Oasis Pilot Study: North Seattle and Bellevue Schools

- OASIS mapped an area in north Seattle, in collaboration with King County Metro, and 5 school ¼ mi walksheds in Bellevue, WA
- OASIS reduced operator time by over 80%
- OASIS Generated mapping data with comparable accuracy to manual on-the-ground vetters
- OASIS Generated mapping data per OpenSidewalks data schema

Yuxiang Zhang, Suresh Devalapalli, Sachin Mehta, Anat Caspi. "OASIS: Automated Assessment of Urban Pedestrian Paths at Scale". The 103rd Transportation Research Board (TRB) Annual Meeting (2024)

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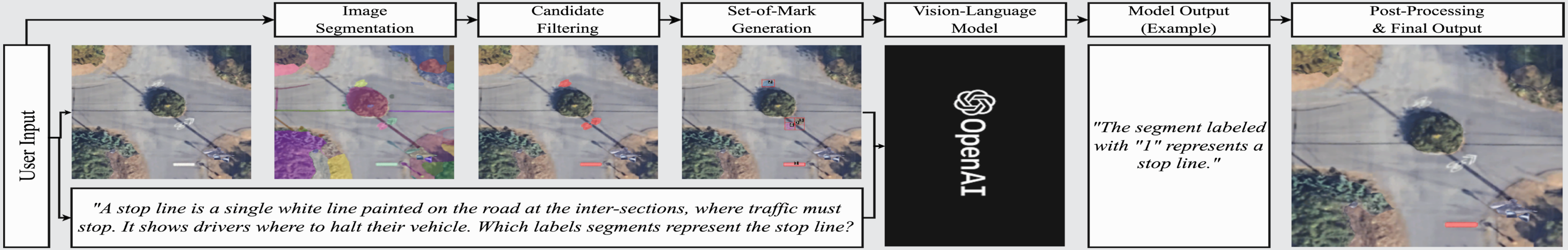
Towards Zero-Shot Annotation of the Built Environment with Vision-Language Models

UNIVERSITY of WASHINGTON

Procedure using VLM to annotate diverse urban features from satellite images at scale, reducing the dependency on human effort

- Remove dependency on costly annotations
- Scale to hundreds of diverse regional features (where no annotations, regardless of cost, could go
- Leverage imagery that has already been acquired and processed



U.S. Department of Transportation
ITS Joint Program Office

Han, B., Yang, Y., Caspi, A., & Howe, B. (2024). Towards Zero-Shot Annotation of the Built Environment with Vision-Language Models (Vision Paper). *arXiv preprint arXiv:2408.00932*. (accepted to SigSpatial, 2024; in proceedings)

Tinyurl.com/2024VLMSidewalks

VLM Procedure On our Imagery

Results

Feature	DP	SoM (NC)	SoM (IC)	SoM (Comb)
Stop Line	0.0000	0.2483	0.3354	0.3657
Raised Table	0.0190	0.3315	0.4069	0.4189

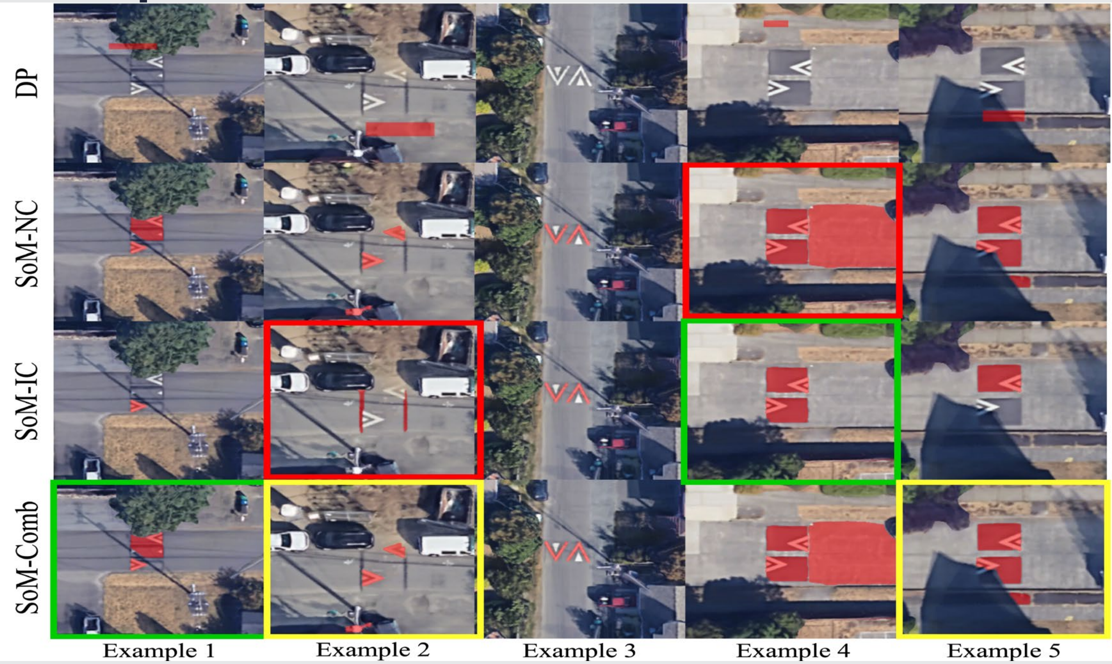
Quantitative:

- Baseline (direct prompting VLM) failed, achieving essentially zero overlap with ground truth.
- Our procedure significantly improves performance, achieving 24%~40% IoU depending on the variant.

Qualitative:

- This procedure guaranteed to identify features partially (always) or Fully (occasionally). Future study to understand feasibility for other features.

Examples



Han, B., Yang, Y., Caspi, A., & Howe, B. (2024). Towards Zero-Shot Annotation of the Built Environment with Vision-Language Models (Vision Paper). *arXiv preprint arXiv:2408.00932*. (accepted to SigSpatial, 2024; in proceedings)

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Deployed Capacity Building Tools

TCAT The Taskar Center for Accessible Technology

OpenSidewalks

Pedestrian-centered approach, data specification and tools to share accessibility information about urban street environments

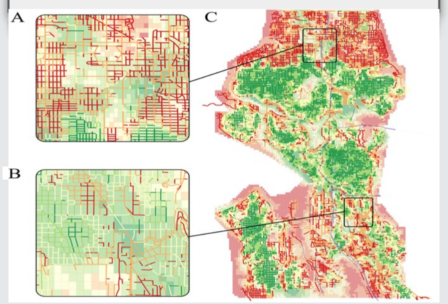
https://sidewalks.washington.edu/

Accessmap.app-
automated custom routing for personal mobility profiles

Transportation Data Equity
an initiative by TCAT & UW TRAC
TDEI

https://transitequity.cs.washington.edu/
TDEI: data sharing Ecosystem for accessibility-first Transportation data

walksheds



https://walkshed.sidewalks.washington.edu/
Walksheds- Urban analytic dashboards for equitable urban planning

Applied AI for OpenSidewalks collection: Summary

- Pedestrian network data is essential to a transportation network.
- The data is hard to collect and maintain manually.
- The UW team presented several AI-based methods to automate sidewalk data collection and mapping, at various scales and with heterogeneous inputs
- The systems provide sidewalk data (in standardized OpenSidewalks format) that will benefit various stakeholders.
- The systems use off-the-shelf components and are easy to replicate and deploy for a larger scale use.
- The systems can also be incorporated into smart city technology and sensor network plans to automate regular city audits and data collections

Any Questions? Anat Caspi & Ricky Zhang uwtcat@uw.edu

Q&A

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