

Project Sidewalk: Mapping the Accessibility of the Physical World **at Scale** using Interactive Computational Tools

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Google Tech Talk

Jan 22, 2020



PAUL G. ALLEN SCHOOL
OF COMPUTER SCIENCE & ENGINEERING

UNIVERSITY *of*
WASHINGTON



30.6

million U.S. adults
have a mobility impairment

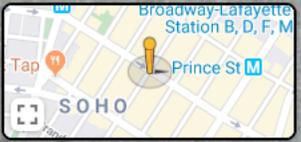


Source: US Census, 2010

15.2

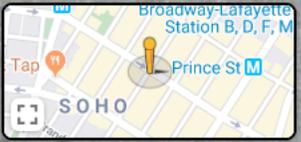
million use an assistive aid







NO CURB RAMPS



PHYSICAL OBSTACLES



SURFACE PROBLEMS





INCOMPLETE SIDEWALKS



PHYSICAL OBSTACLES

NO CURB RAMP

SURFACE DEGRADATION



Accessible infrastructure
has a significant impact
on the **independence**
and **mobility of citizens**

[Thapar *et al.*, 2004 ; Nuernberger, 2008]



The National Council on Disability noted that there is **no comprehensive information** on “the degree to which sidewalks are accessible” in cities.



National Council on Disability, 2007

The impact of the Americans with Disabilities Act: Assessing the progress toward achieving the goals of the ADA

OUR VISION

Design systems that transform the way urban accessibility information is **collected** and **utilized**.



Reset View

WELCOME TO ACCESS SCORE

Interactive Visual Exploration of Physical Accessibility

Start exploring the accessibility of Washington DC by dragging the  cursor into a rectangular box over the map.



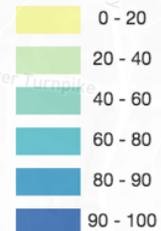
The selected regions will be colored based on their accessibility scores. More information for the selected regions will be shown on the right sidebar panel. Click on any specific region to know more about a neighborhood.

Start Coloring!

Data Coverage: **100%**
Average Access Score: **89.7**

[Know More](#)

Access Scores



Least accessible (low score) to most accessible (high score)

Green-Yellows indicate inaccessible neighborhoods

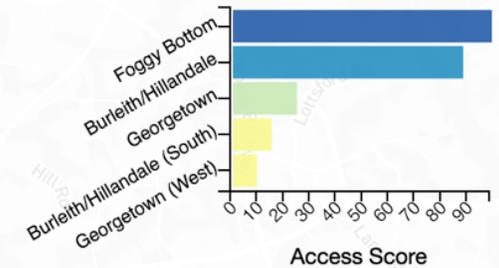
Blues indicate an accessible neighborhoods

Showing information for the selected area

Georgetown
24.5

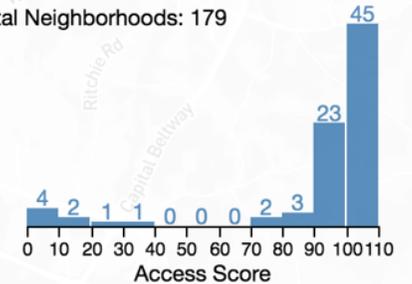
Average score **88.9**

Top 5 accessible regions



Histogram of Access Scores

Total Neighborhoods: 179



INTERACTIVE VISUALIZATION OF ACCESSIBILITY DATA



from Lincoln Memorial Cir NW

to Washington Monument



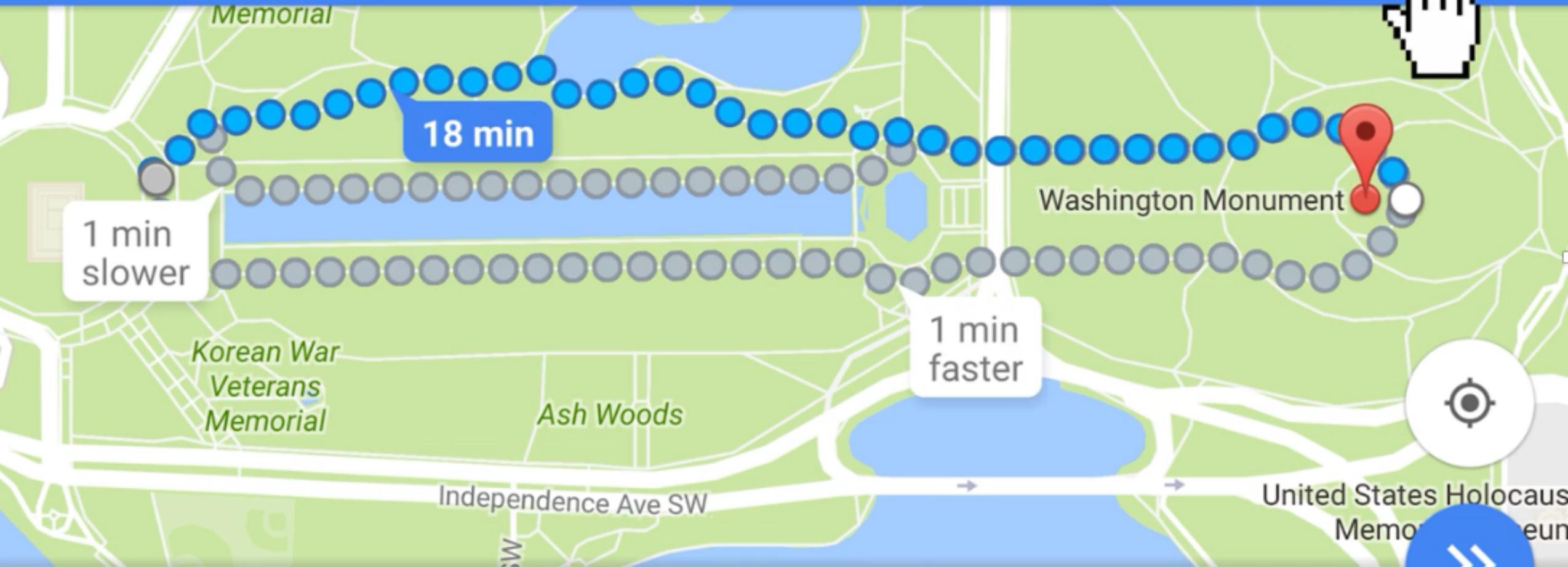
19 min

17 min

4 min

8 min

18 min



18 min (0.9 mi) via Lincoln Memorial Cir NW

ACCESSIBILITY-AWARE ROUTING

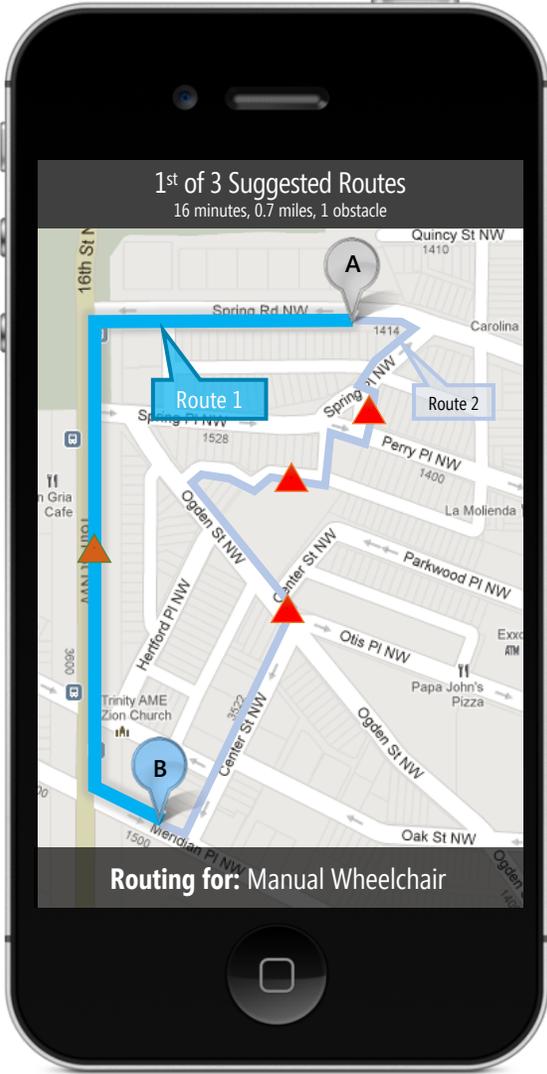


MOTIVATION

ACCESSIBILITY-AWARE ROUTING

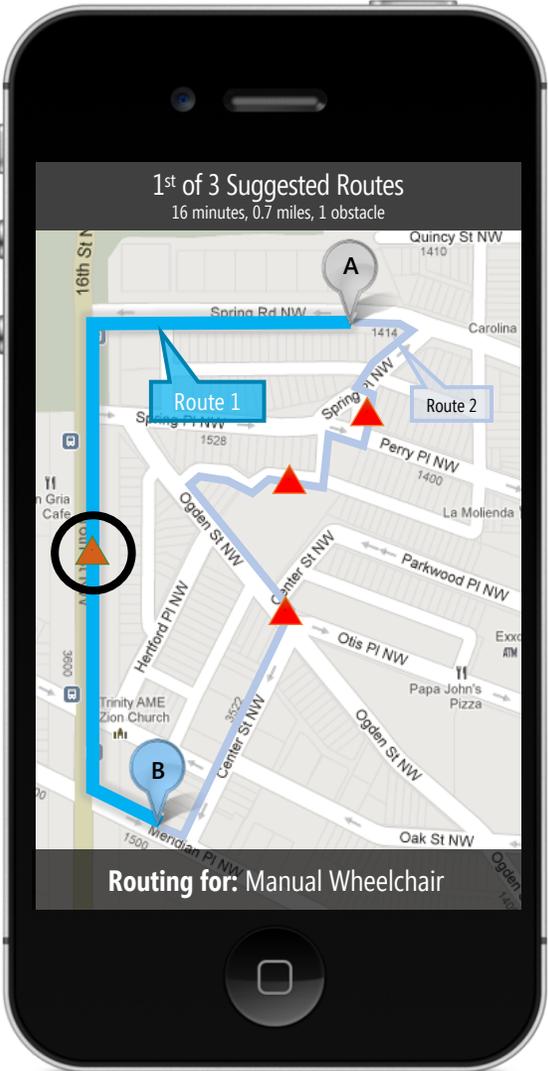


Showing alternate routes tailored to a person



MOTIVATION

ACCESSIBILITY-AWARE ROUTING



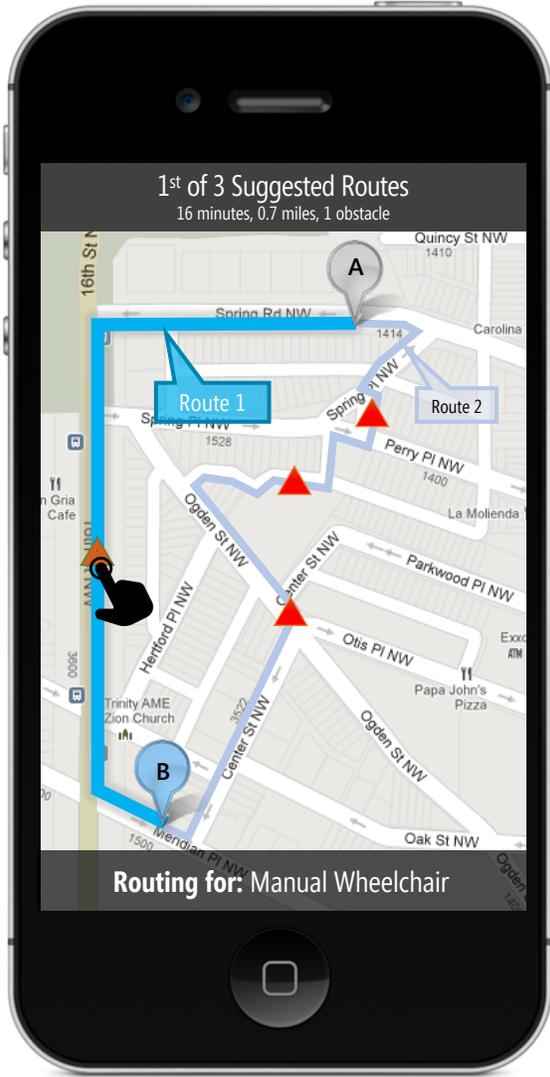
Investigating mobility barriers along the route

MOTIVATION

ACCESSIBILITY-AWARE ROUTING



Investigating mobility barriers along the route

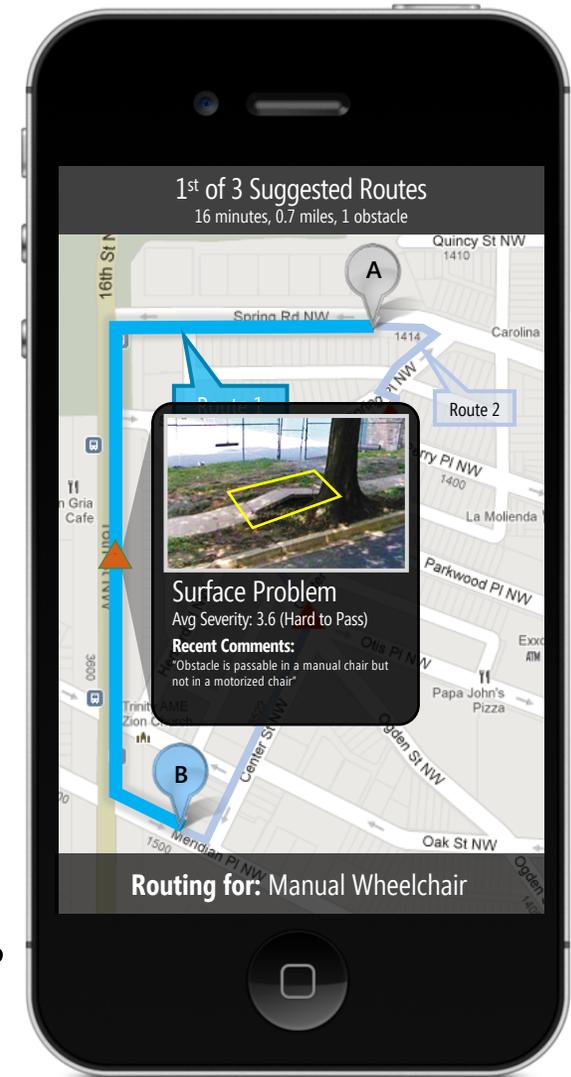


MOTIVATION

ACCESSIBILITY-AWARE ROUTING



Investigating mobility barriers along the route



THESE APPLICATIONS HAVE

**HUGE
DATA**

REQUIREMENTS

THESE APPLICATIONS HAVE

**HUGE
DATA**

REQUIREMENTS



*How do we get
this data?*

Traditional Physical Audits



Walkability Audit
Wake County, North Carolina

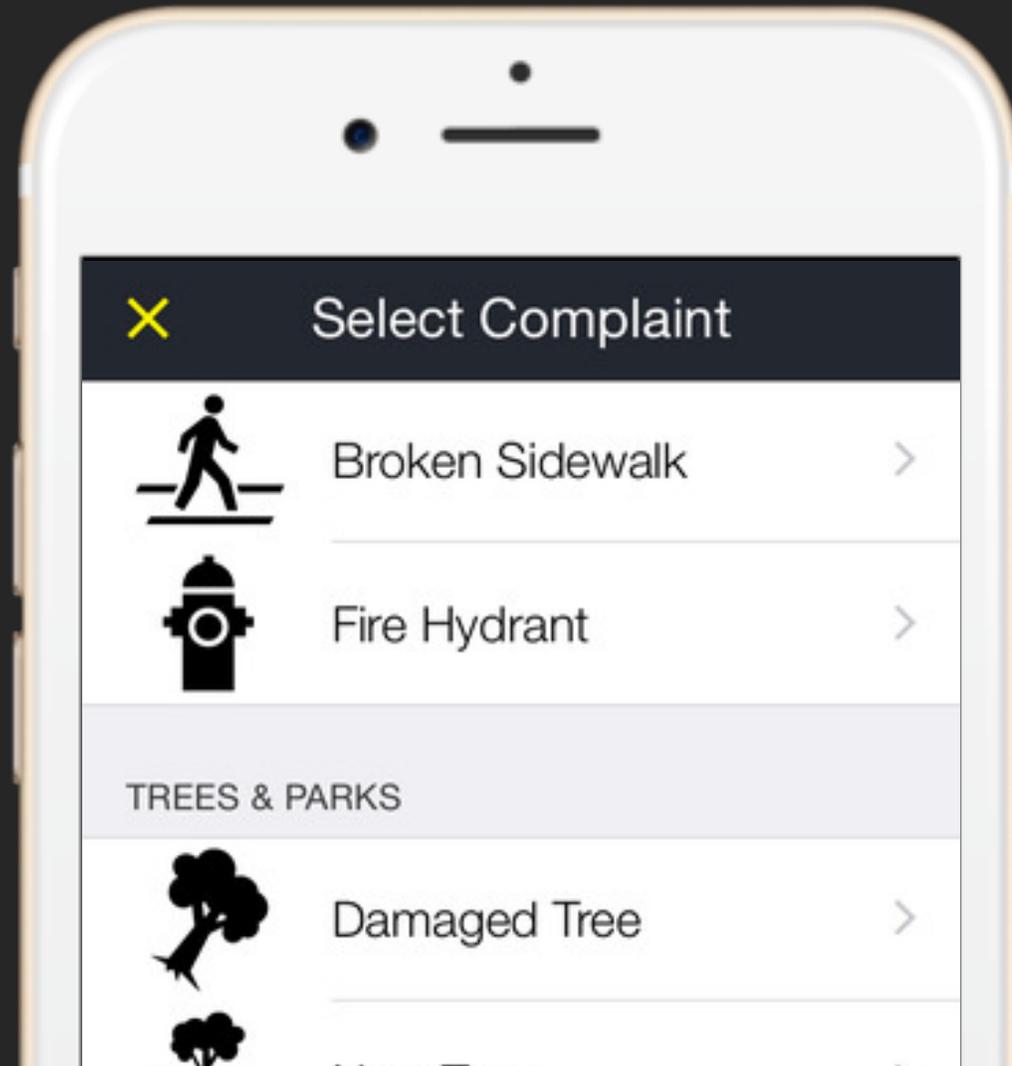


Walkability Audit
Wake County, North Carolina



Safe Routes to School Walkability Audit
Rock Hill, South Carolina

Mobile Reporting Solutions



MOTIVATION

CHALLENGES OF TRADITIONAL DATA COLLECTION APPROACHES?



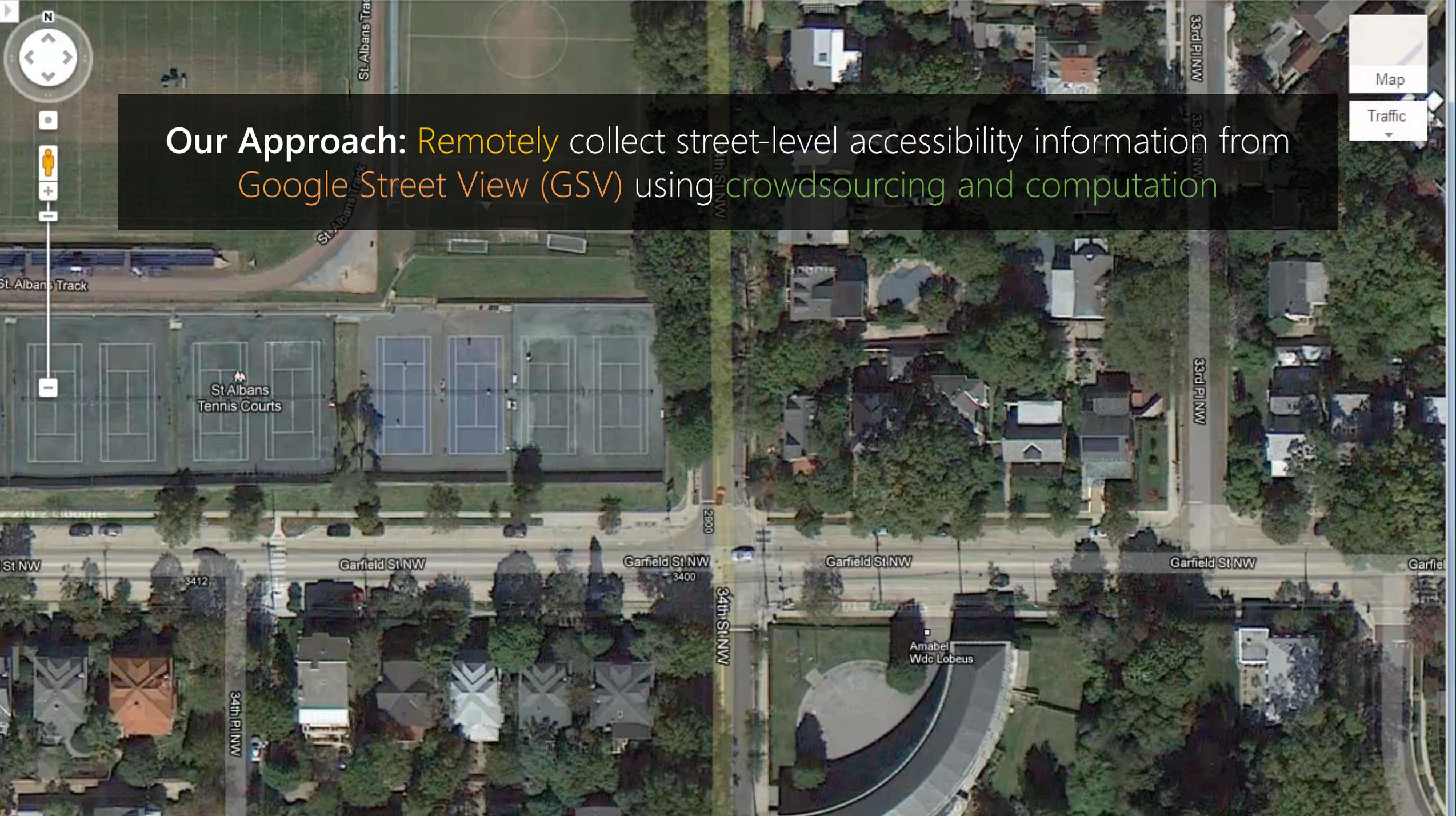
Slow, Manual, and Laborious



Huge Cost



Localized



Our Approach: Remotely collect street-level accessibility information from Google Street View (GSV) using crowdsourcing and computation

TALK OUTLINE

TALK OUTLINE

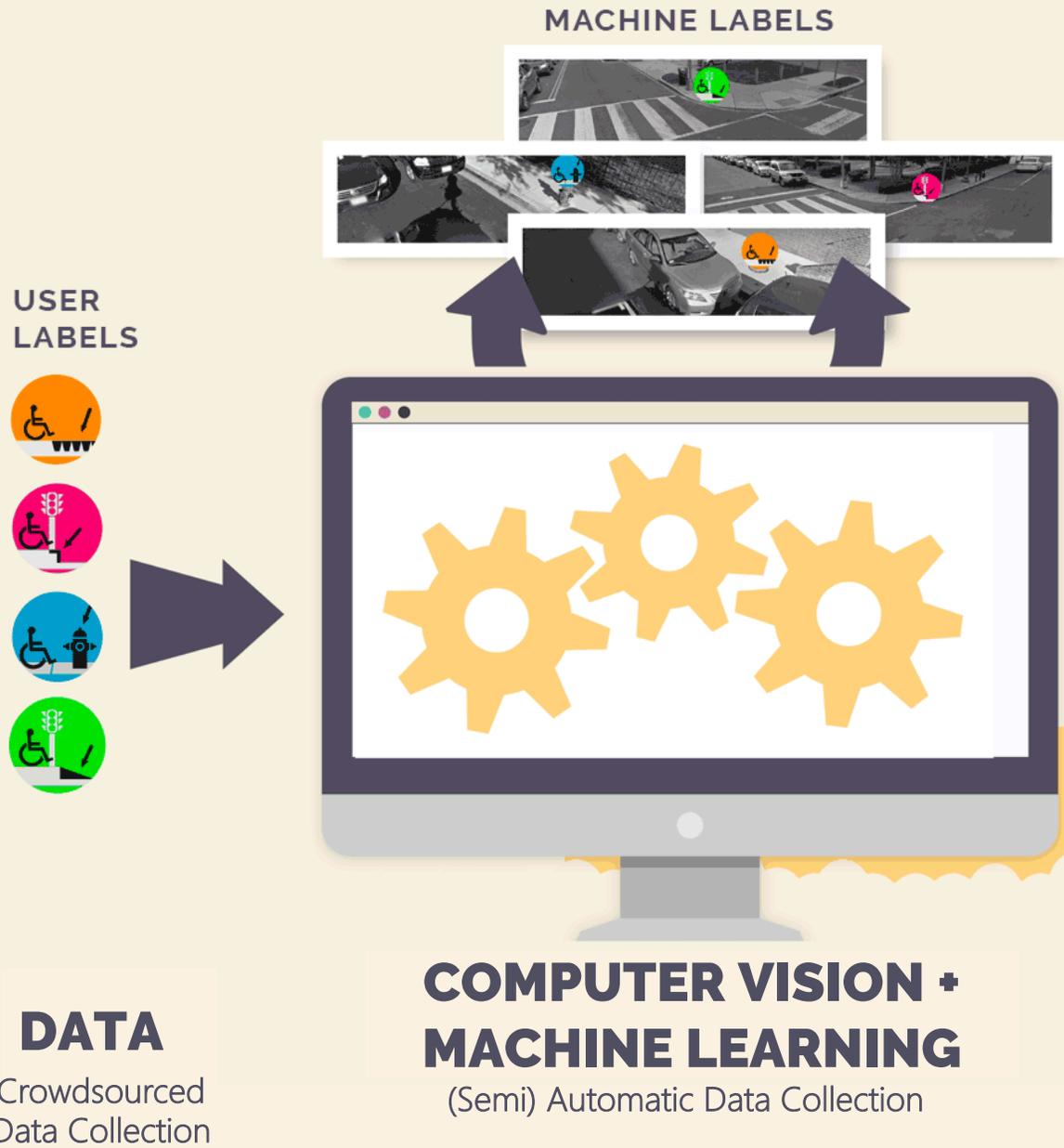
USER LABELS



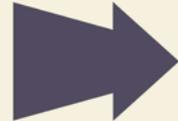
DATA

Crowdsourced
Data Collection

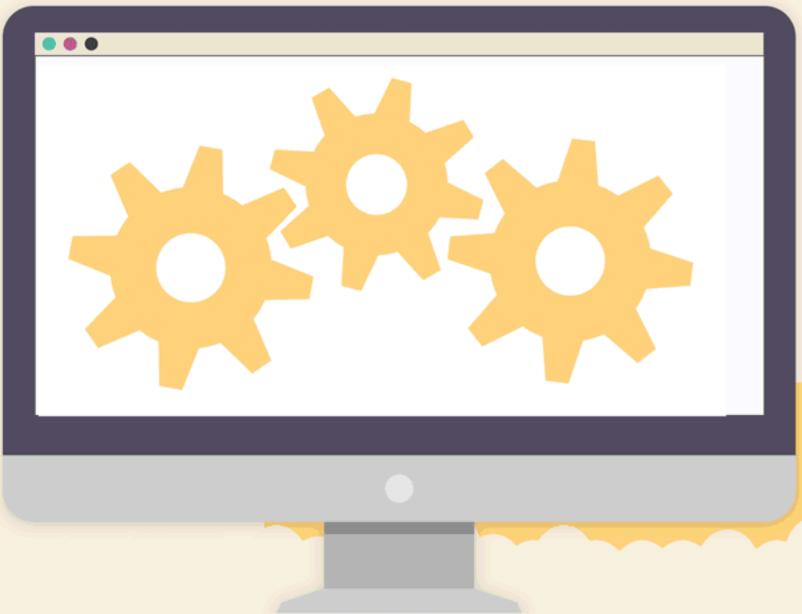
TALK OUTLINE



USER LABELS



MACHINE LABELS



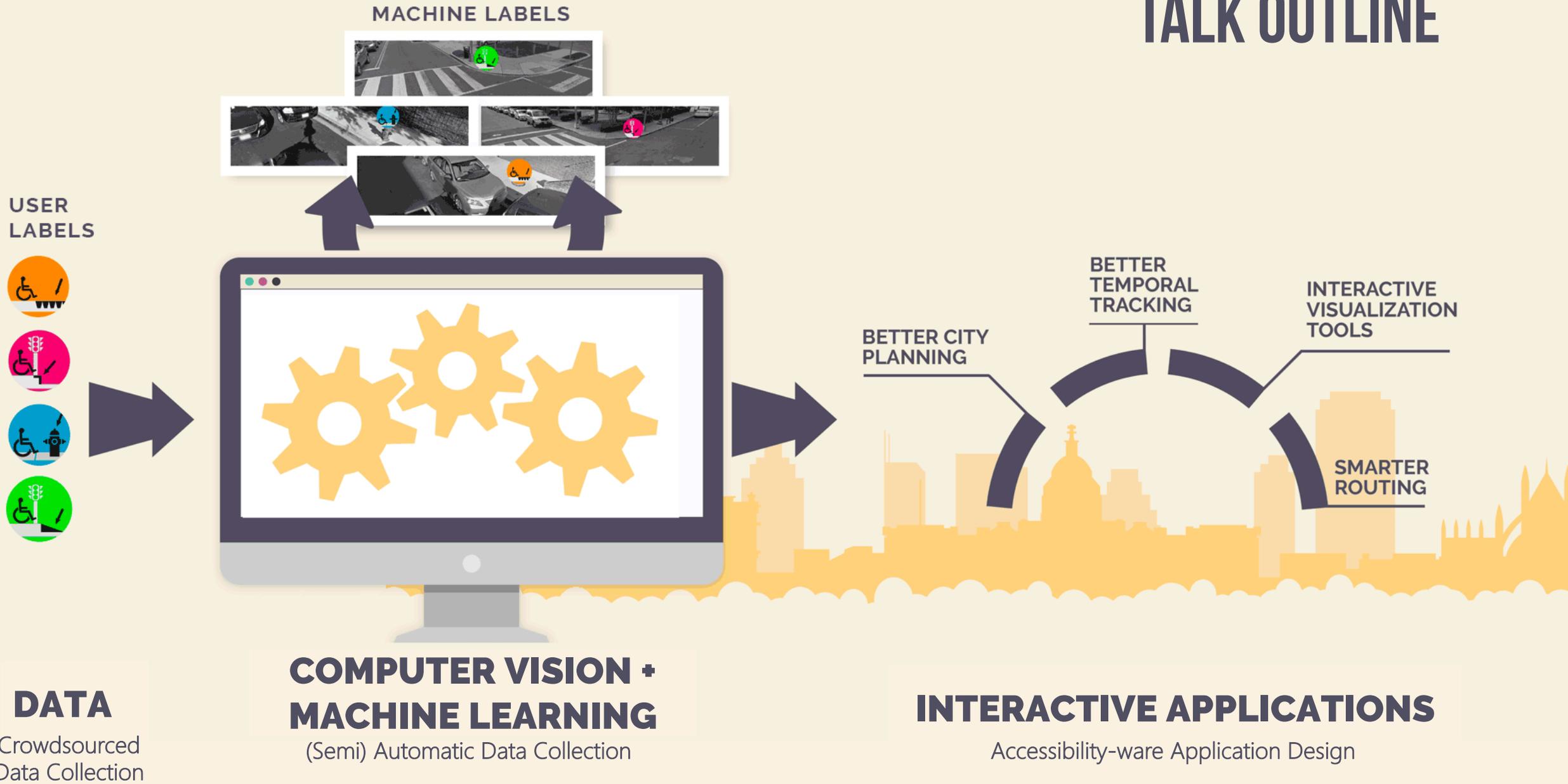
**COMPUTER VISION +
MACHINE LEARNING**

(Semi) Automatic Data Collection

DATA

Crowdsourced
Data Collection

TALK OUTLINE

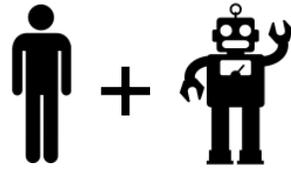


THIS TALK WILL BE...



Crowdsourced
Data Collection

50%



(semi) Automated
Data Collection

20%

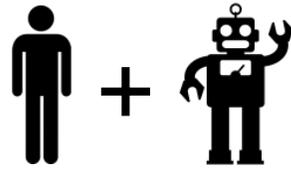


Accessibility-aware
Application Design

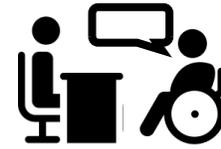
30%



Crowdsourced
Data Collection



(semi) Automated
Data Collection



Accessibility-aware
Application Design



Crowdsourced
Data Collection



(semi) Automated
Data Collection



Accessibility-aware
Application Design

1. How can we design a crowdsourcing system to collect street-level accessibility data from Google Street View?
2. How to quickly train crowd workers to accurately label accessibility features in Google Street View imagery?



PROJECT
SIDEWALK

[HTTP://PROJECTSIDEWALK.IO](http://PROJECTSIDEWALK.IO)

<http://projectsidewalk.io>

Let's create a path for everyone

Start Exploring Seattle

We are also in: [Newberg, OR](#) [Washington, DC](#)

Interactive tool that empowers **anyone** to **virtually** walk city streets and **remotely** label accessibility problems

<http://projectsidewalk.io>

Let's create a path for everyone

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Let's create a path for everyone

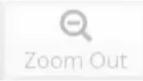
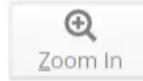
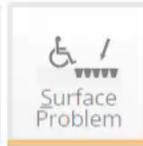
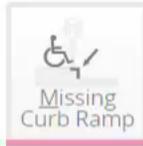
[Start Exploring Seattle](#)

We are also in: [Newberg, OR](#) [Washington, DC](#)

Interactive tool that empowers **anyone** to **virtually** walk city streets and **remotely** label accessibility problems

TOOL WALKTHROUGH

Find and label the following



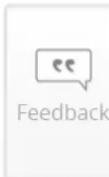
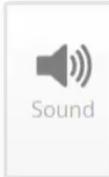
Current Neighborhood
Fort Stanton, D.C.

Audit 1000ft of Fort Stanton



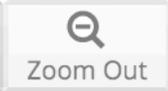
Your mission is to audit 1000ft of Fort Stanton and find all the accessibility features that affect mobility impaired travelers!

OK



TOOL WALKTHROUGH

Find and label the following



Current Neighborhood
Fort McNair, D.C.

0.0 miles 0 labels

Audit the streets and find all the accessibility attributes



Current Mission

Audit 1000ft of this neighborhood

15% complete



2 curb ramps



0 missing curb ramp



0 surface problem

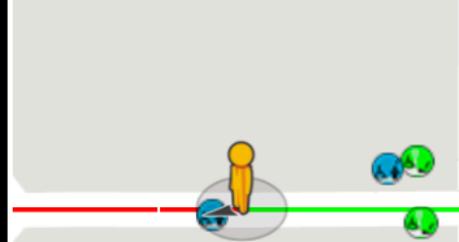


2 obstacles



0 other

Follow the red line



Do you see any unlabeled problems? If not,

Turn slightly towards right

TOOL WALKTHROUGH

Find and label the following

Explore Curb Ramp Missing Curb Ramp Obstacle in Path Surface Problem Other

Zoom In

GSV exploration and labeling pane

Current Neighborhood
Fort McNair, D.C.

0.0 miles 0 labels

Current Mission
Audit 1000ft of this neighborhood
15% complete

2 curb ramps
0 missing curb ramp
0 surface problem
2 obstacles
0 other

Follow the red line

Audit the streets and find all the accessibility attributes



Do you see any unlabeled problems? If not,
Turn slightly towards right
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TOOL WALKTHROUGH



Explore



Curb Ramp



Missing Curb Ramp



Obstacle in Path

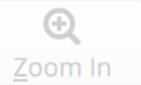


Surface Problem



Other

Find and label the following



Zoom In



Zoom Out



Undo



Redo

Current Neighborhood
Fort McNair, D.C.

0.0 miles 0 labels

Audit the streets and find all the accessibility attributes

Labeling button menu bar



Current Mission

Audit 1000ft of this neighborhood

15% complete



2 curb ramps



0 missing curb ramp



0 surface problem

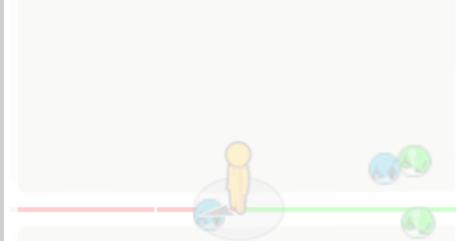


2 obstacles



0 other

Follow the red line



Do you see any unlabeled problems? If not,

Turn slightly towards right

Google

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Google

Map data ©2017 Google Terms of Use

Feedback

TOOL WALKTHROUGH

Find and label the following

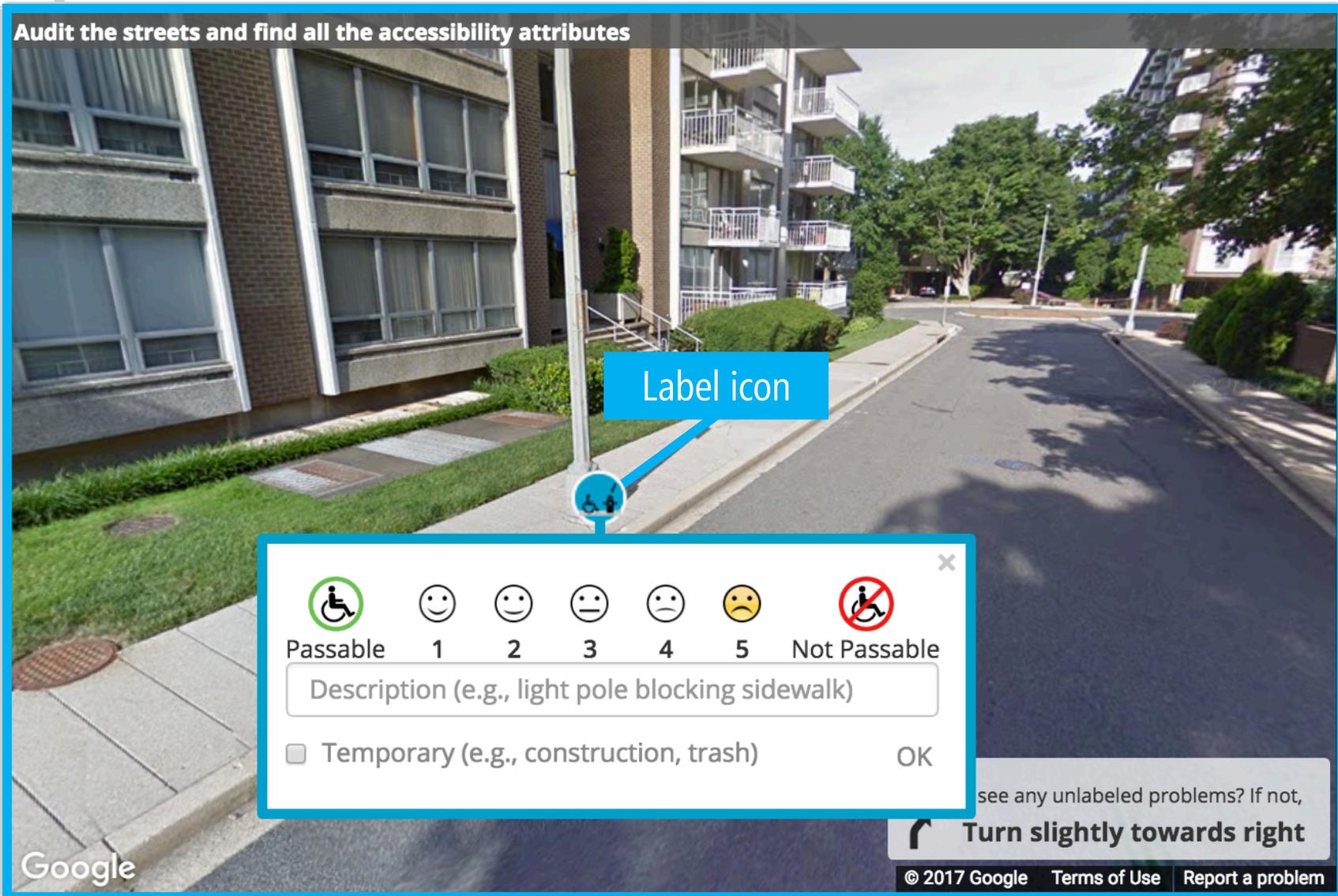
Explore | Curb Ramp | Missing Curb Ramp | Obstacle in Path | Surface Problem | Other | Zoom In | Zoom Out | Undo | Redo

Current Neighborhood
Fort McNair, D.C.

0.0 miles 0 labels

Current Mission
Audit 1000ft of this neighborhood
15% complete

- 2 curb ramps
- 0 missing curb ramp
- 0 surface problem
- 2 obstacles
- 0 other

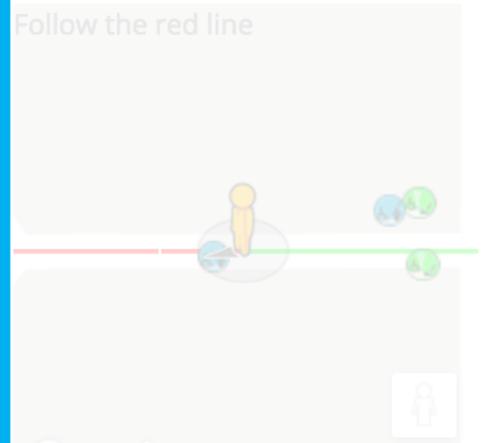


Passable 1 2 3 4 5 Not Passable

Description (e.g., light pole blocking sidewalk)

Temporary (e.g., construction, trash) OK

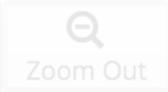
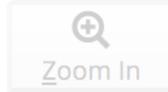
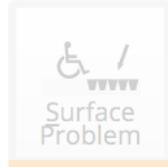
see any unlabeled problems? If not,
Turn slightly towards right



Google

TOOL WALKTHROUGH

Find and label the following



Current Neighborhood
Fort McNair, D.C.

0.0 miles 0 labels

Current Mission

Audit 1000ft of this neighborhood

15% complete



2 curb ramps



0 missing curb ramp



2 obstacles

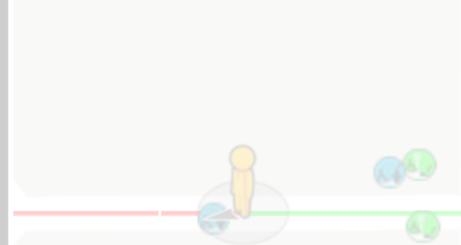


0 surface problem

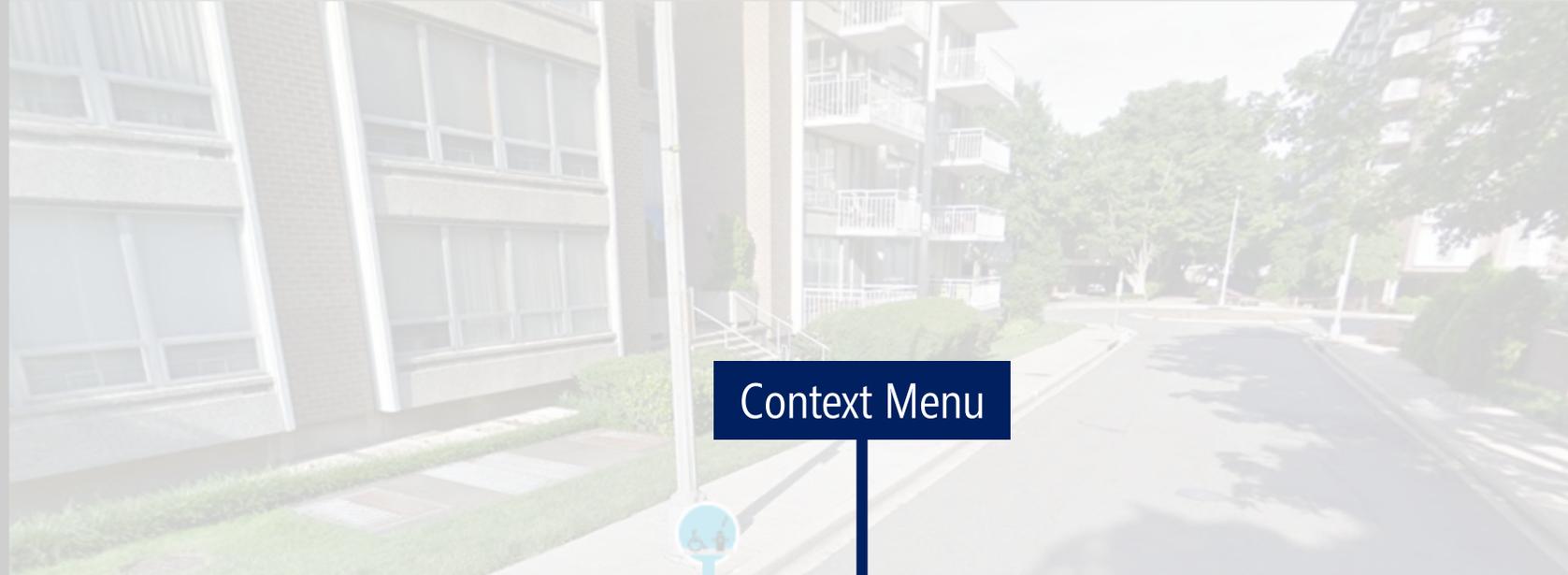


0 other

Follow the red line



Audit the streets and find all the accessibility attributes



Context Menu

Passable 1 2 3 4 5 Not Passable

Description (e.g., light pole blocking sidewalk)

OK

Severity Rating

Description

Feedback

Google

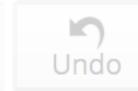
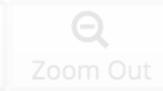
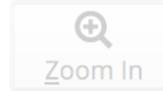
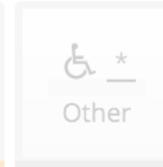
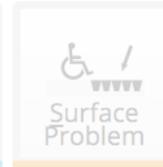
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Google

Map data ©2017 Google Terms of Use

TOOL WALKTHROUGH

Find and label the following



Audit the streets and find all the accessibility attributes



Progress bar

Contributions

Mission Progress Pane

Current Neighborhood
Fort McNair, D.C.

0.0 miles 0 labels

Current Mission
Audit 1000ft of this neighborhood

15% complete

2	2
0	0
0	0

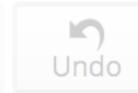
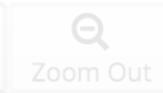
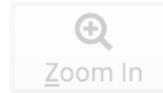
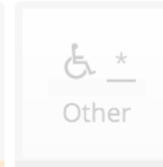
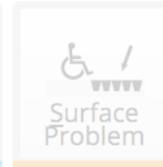
Follow the red line

Google
Map data ©2017 Google | Terms of Use

Do you see any unlabeled problems? If not,
 Turn slightly towards right

TOOL WALKTHROUGH

Find and label the following



Current Neighborhood
Fort McNair, D.C.

0.0 miles 0 labels

Current Mission
Audit 1000ft of this neighborhood
15% complete

- 2 curb ramps
- 0 missing curb ramp
- 2 obstacles

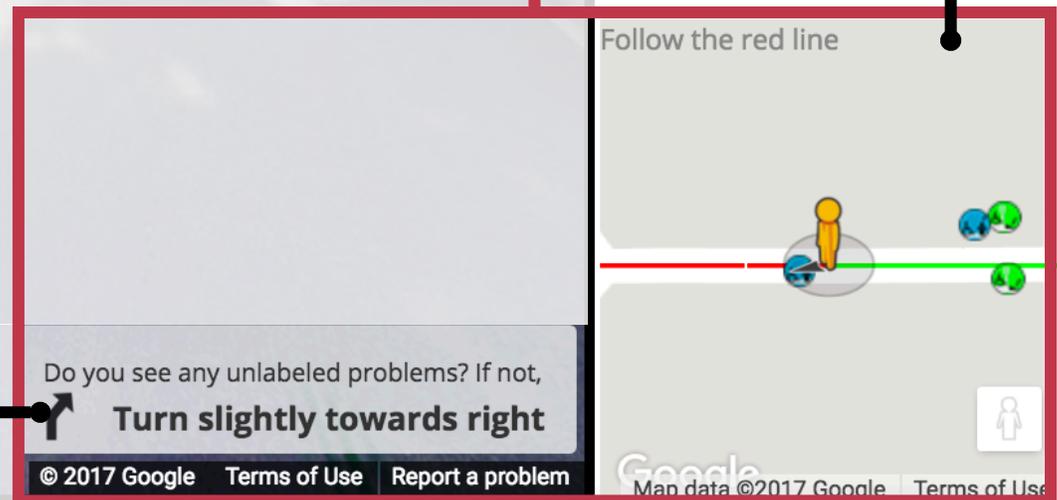
Audit the streets and find all the accessibility attributes



Obstacle in Path

Route Guidance

Top-down map



Follow the red line

Do you see any unlabeled problems? If not,
Turn slightly towards right

Turn-by-turn directions

Feedback

Google

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Google Map data ©2017 Google Terms of Use

PROJECT SIDEWALK SYSTEM

INTERACTIVE TUTORIAL

Find and label the following

- Explore
- Curb Ramp**
- Missing Curb Ramp
- Obstacle in Path
- Surface Problem
- No Sidewalk
- Other

Zoom In Zoom Out

Current Neighborhood
Woodridge, D.C.

0.0 miles 0 labels

In this Street View image, we have drawn an arrow to a curb ramp. Let's label it. Click the flashing "Curb Ramp" button above.



Current Mission
Complete the onboarding tutorial!

- 0 curb ramp
- 0 surface problem
- 0 missing curb ramp
- 0 no sidewalk
- 0 obstacle
- 0 other

1



PROJECT SIDEWALK SYSTEM

INTERACTIVE TUTORIAL

Find and label the following

Explore Curb Ramp Missing Curb Ramp Obstacle in Path Surface Problem No Sidewalk Other

Zoom In Zoom Out

Current Neighborhood
Woodridge, D.C.
0.0 miles 1 labels

Current Mission
Complete the onboarding tutorial!
8% complete

1 curb ramp 0 surface problem
0 missing curb ramp 0 no sidewalk
0 obstacle 0 other

2

Now, you can rate the quality of the curb ramp where 1 is passable and 5 is not passable for a wheelchair user. **Let's rate it as 1, passable.**

Passable 1 2 3 4 5 Not Passable

Description (e.g., narrow curb ramp)

Temporary (e.g., construction, trash) OK



Follow the red line

Map data ©2019 Google Terms of Use

INTERACTIVE TUTORIAL

Find and label the following

- Explore
- Explore
- Explore
- Explore
- Curb Ramp
- Missing Curb Ramp
- Obstacle in Path
- Surface Problem
- No Sidewalk
- Other

Zoom In Zoom Out

Current Neighborhood
Woodridge, D.C.

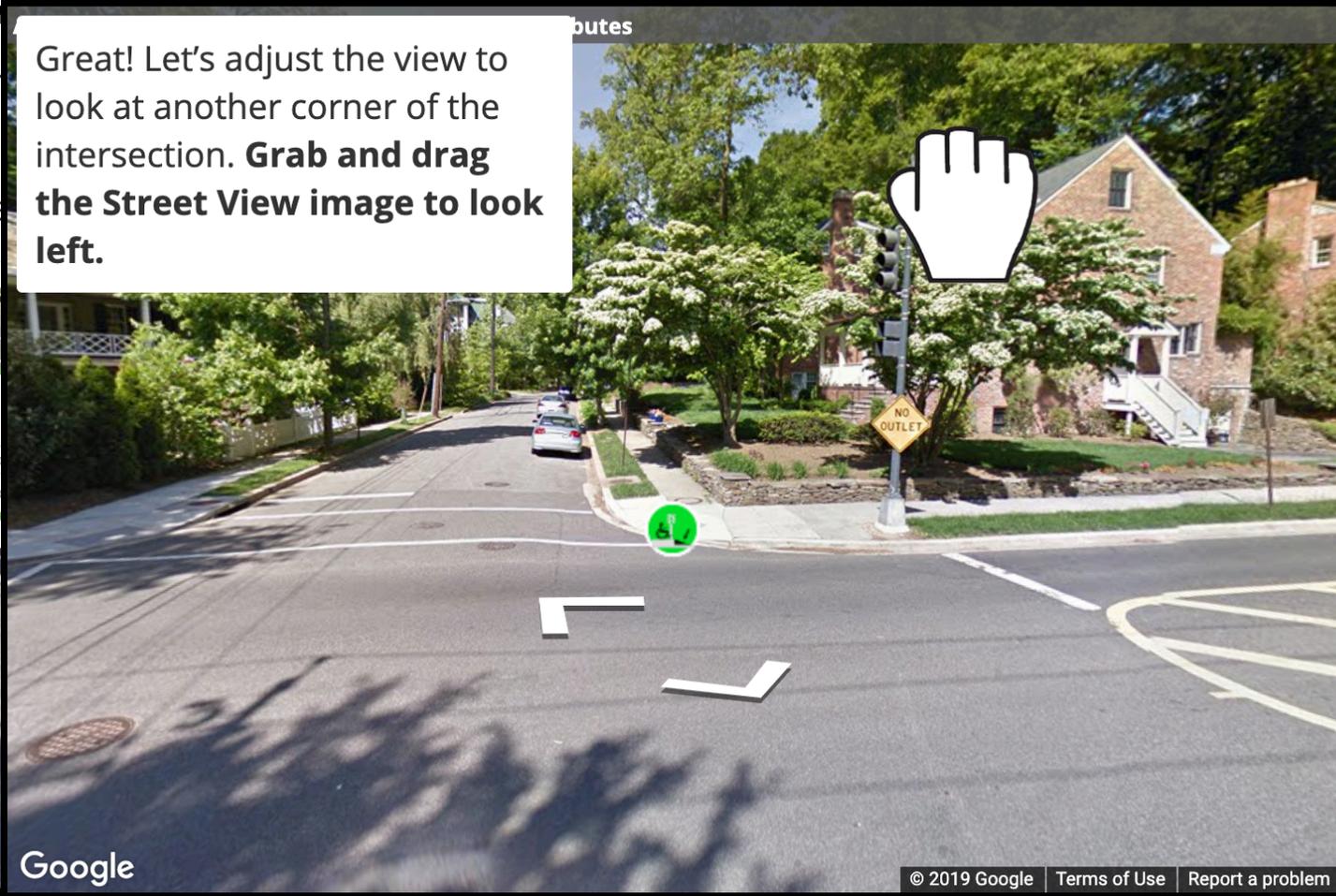
0.0 miles 1 labels

Current Mission
Complete the onboarding tutorial

1 curb ramp	0 surface problem
0 missing curb ramp	1 sidewalk
0 obstacle	0 other

3

Great! Let's adjust the view to look at another corner of the intersection. **Grab and drag the Street View image to look left.**



1

2

Google

INTERACTIVE TUTORIAL

Find and label the following

- Explore
- Curb Ramp
- Missing Curb Ramp
- Obstacle in Path
- Surface Problem
- No Sidewalk
- Other

Zoom In Zoom Out

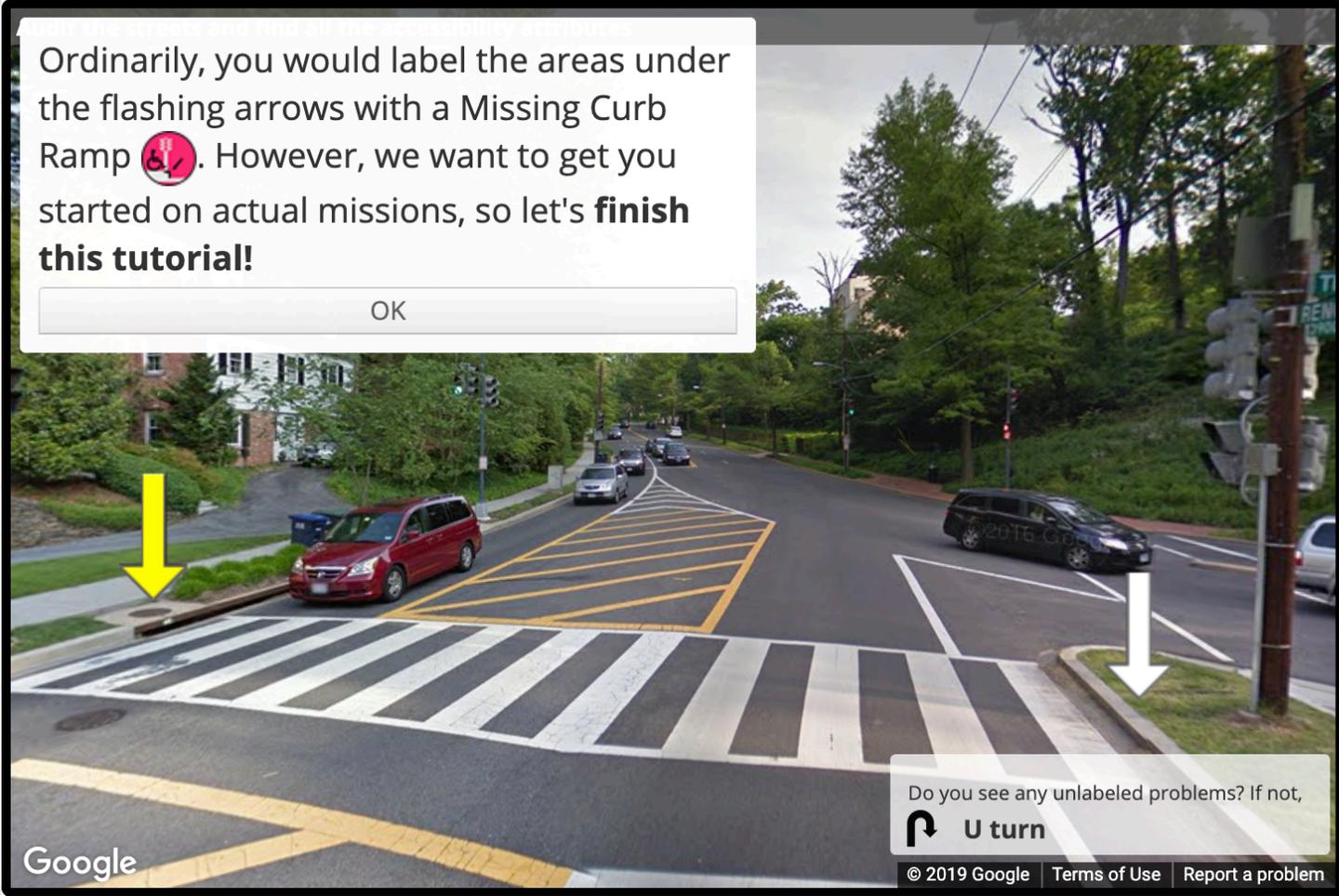
Current Neighborhood
Golden Triangle, D.C.
0.0 miles 7 labels

Current Mission
Complete the onboarding tutorial!
89% complete

- 5 curb ramps
- 1 missing curb ramp
- 0 obstacle
- 0 surface problem
- 1 no sidewalk
- 0 other

Ordinarily, you would label the areas under the flashing arrows with a Missing Curb Ramp . However, we want to get you started on actual missions, so let's **finish this tutorial!**

OK



Do you see any unlabeled problems? If not, U turn

Follow the red line

Map data ©2019 Google Terms of Use

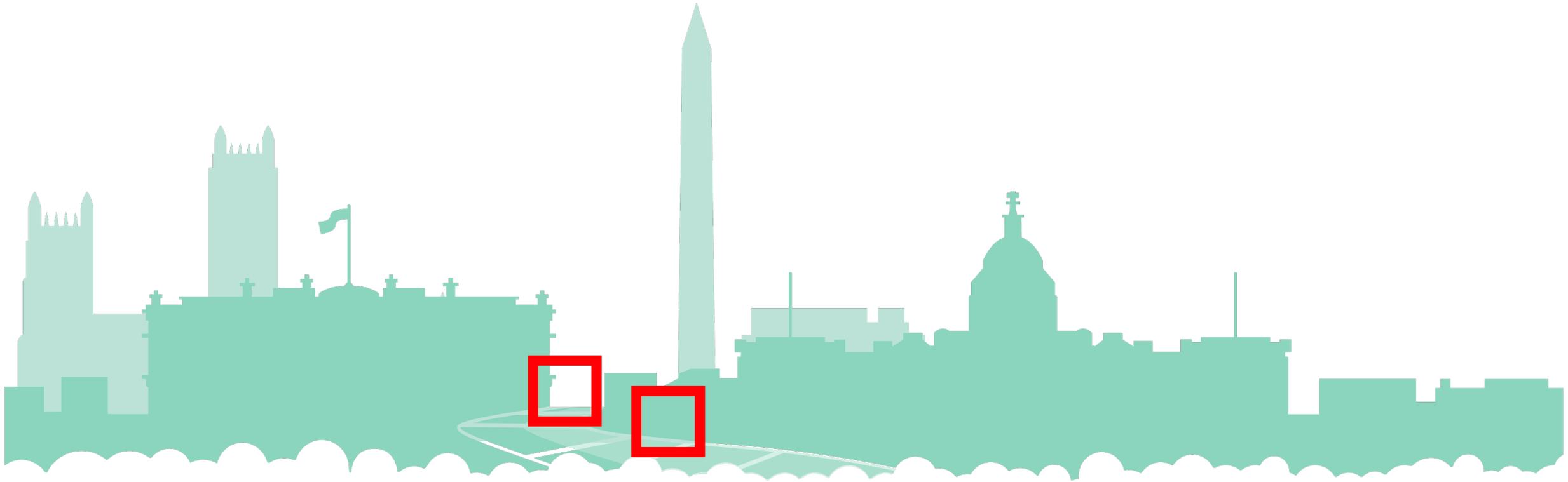
In this Street View...
Now, you...
Great! Let's adjust...
1 2 3 ...

PROJECT SIDEWALK SYSTEM

DEPLOYMENT

CHI 2019, BEST PAPER

Washington DC



18-month deployment ~ Fall **2016** - Spring **2018**

PROJECT SIDEWALK SYSTEM: DC DEPLOYMENT

DATA COLLECTED

CHI 2019, BEST PAPER

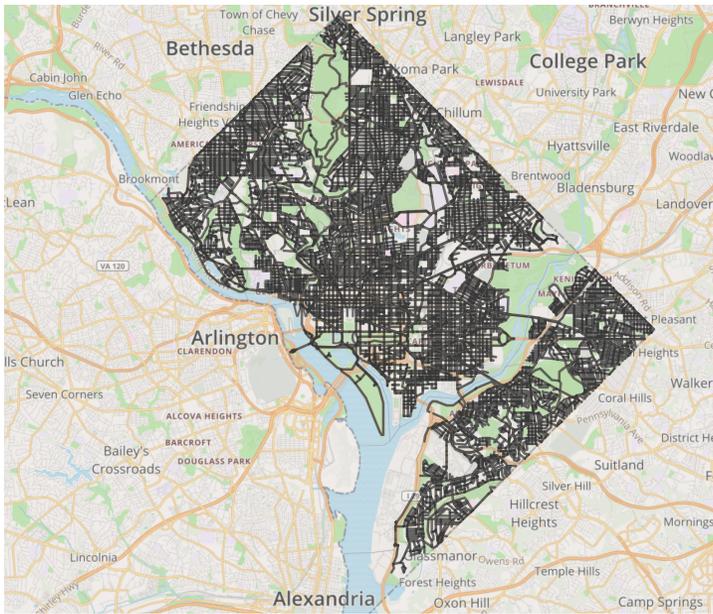


~800

USERS

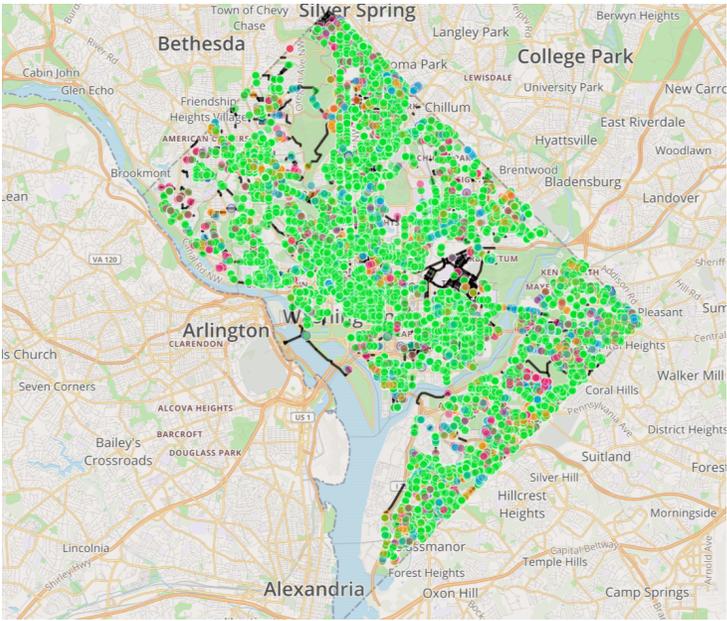
Volunteers

Turkers



~3000

MILES



250,000+

LABELS

LABEL EXAMPLES

CHI 2019, BEST PAPER



142,835
Curb Ramps

18,719
Missing Curb Ramps

21,736
Obstacles

8309
Surface Problems

MORE CITIES!

Newberg, OR



100%

Newberg mapped

107

miles covered



16,930

labels

MORE CITIES!

Seattle, WA



47%

Seattle mapped

880

miles covered

89,000+

labels

MORE CITIES!



Columbus, OH
Late 2019



Mexico City, Mexico
2020 soon!

Downtown

PROJECT SIDEWALK SYSTEM

OPEN SOURCE & OPEN DATA

The screenshot shows the GitHub repository page for Project Sidewalk. At the top, there are navigation links for Pull requests, Issues, Marketplace, and Explore. The repository name 'Project Sidewalk' is prominently displayed, along with a description: 'Project Sidewalk is operated by the Makeability Lab at the University of Washington and University of Maryland, College Park'. Below this, there are statistics for Repositories (14), People (15), Teams (1), and Projects (0). A search bar for repositories is present, along with filters for Type and Language. Several repository cards are visible, including 'SidewalkWebpage', 'Sidewalk_CV', 'sidewalk-data-analysis', and 'SidewalkWebpageDC'. On the right side, there are sections for 'Top languages' (JavaScript, HTML, Shell, Python, Java) and 'People' (a grid of profile pictures).

<https://github.com/ProjectSidewalk>

The screenshot shows the API documentation page for Project Sidewalk. At the top, there is a 'Start Mapping' button and the name 'Jon Froehlich'. The page is divided into two main sections: 'Access Features' and 'Access Score: Streets'. Each section includes a map showing the geographic area of interest, followed by a description of the API's purpose and the data it returns. The 'Access Features' section provides details on the URL, method (GET), and required parameters (lat1, lng1, lat2, lng2). The 'Access Score: Streets' section provides similar details for a different API endpoint. Both sections include an 'Example' URL demonstrating how to use the API.

<http://projectsidewalk.io/api>

KEY STAKEHOLDERS



People with Mobility Impairments



Accessibility Advocates



Government Officials



Caregivers

Elected Officials
and other policymakers

DOTs

KEY STAKEHOLDERS



People with Mobility Impairments



Caregivers



People affected by
inaccessible infrastructure



Elected Officials
and other policymakers

DOTs

KEY STAKEHOLDERS

People who can bring change i.e., improve accessibility



Caregivers



Accessibility Advocates



Government Officials

Elected Officials and other policymakers

DOTs

KEY STAKEHOLDERS



People with Mobility Impairments



Accessibility Advocates



Government Officials



Caregivers

Elected Officials
and other policymakers

DOTs

PROJECT SIDEWALK SYSTEM

STAKEHOLDER PERCEPTIONS AND CONCERNS

Perceived Value

Concerns



WHAT ARE THE STAKEHOLDERS' PERCEPTIONS AND CONCERNS?

Perceived Value

Enabled rapid data collection

Gathered diverse perspectives about accessibility

Helped engage citizens in thinking about urban design

WHAT ARE THE STAKEHOLDERS' PERCEPTIONS AND CONCERNS?

Perceived Value

“

It's really good for a starting point. This is a first observation, and when you send somebody out in the field, they can see those observations and pick up more information. It's just neat!

-G4 ”

WHAT ARE THE STAKEHOLDERS' PERCEPTIONS AND CONCERNS?

Concerns

Data age i.e., outdated GSV imagery or labels

Data reliability

Diverse and conflicting perspectives

WHAT ARE THE STAKEHOLDERS' PERCEPTIONS AND CONCERNS?

Concern: Data Reliability

“

I would have more confidence if different people did it, did the same street.

-G4 ”



Multi-user routing



Data validations

WHAT ARE THE STAKEHOLDERS' PERCEPTIONS AND CONCERNS?

Concern: Data Reliability

“

I would have more confidence in the data if other people did it, did the same thing.

Multi-user routing



Data validations

WHAT ARE THE STAKEHOLDERS' PERCEPTIONS AND CONCERNS?

Concern: Diverse and Conflicting Perspectives

“

My concern as a user [is that] someone said this was accessible and I got there and it wasn't accessible, because everyone has different opinions on accessibility.

-MI1 ”



Visual Evidence via
Labeled GSV images



Parameterizable
accessibility models



Crowdsourced
Data Collection



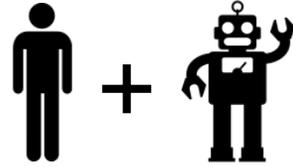
(semi) Automated
Data Collection



Accessibility-aware
Application Design



Crowdsourced
Data Collection



(semi) Automated
Data Collection



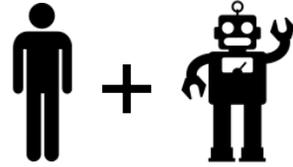
Accessibility-aware
Application Design



1. How can we use computer vision to automatically and accurately detect accessibility attributes?
2. How can we combine crowdsourcing and computer vision to increase the data collection efficiency?



Crowdsourced
Data Collection



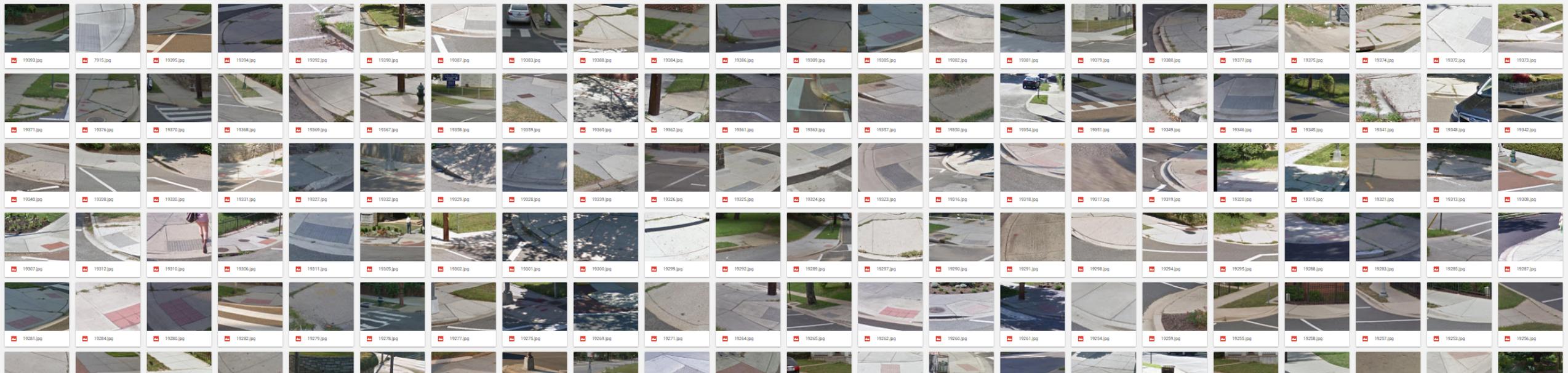
(semi) Automated
Data Collection



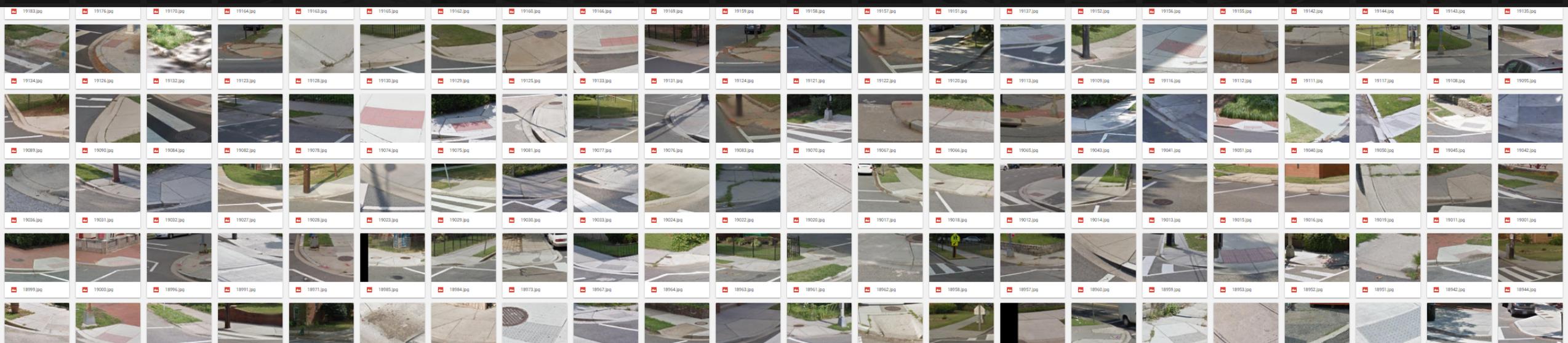
Accessibility-aware
Application Design



1. How can we use computer vision to automatically and accurately detect accessibility attributes?
2. How can we combine crowdsourcing and computer vision to increase the data collection efficiency?



Automating Data Collection using Computer Vision



COMPUTER VISION-BASED TECHNIQUES

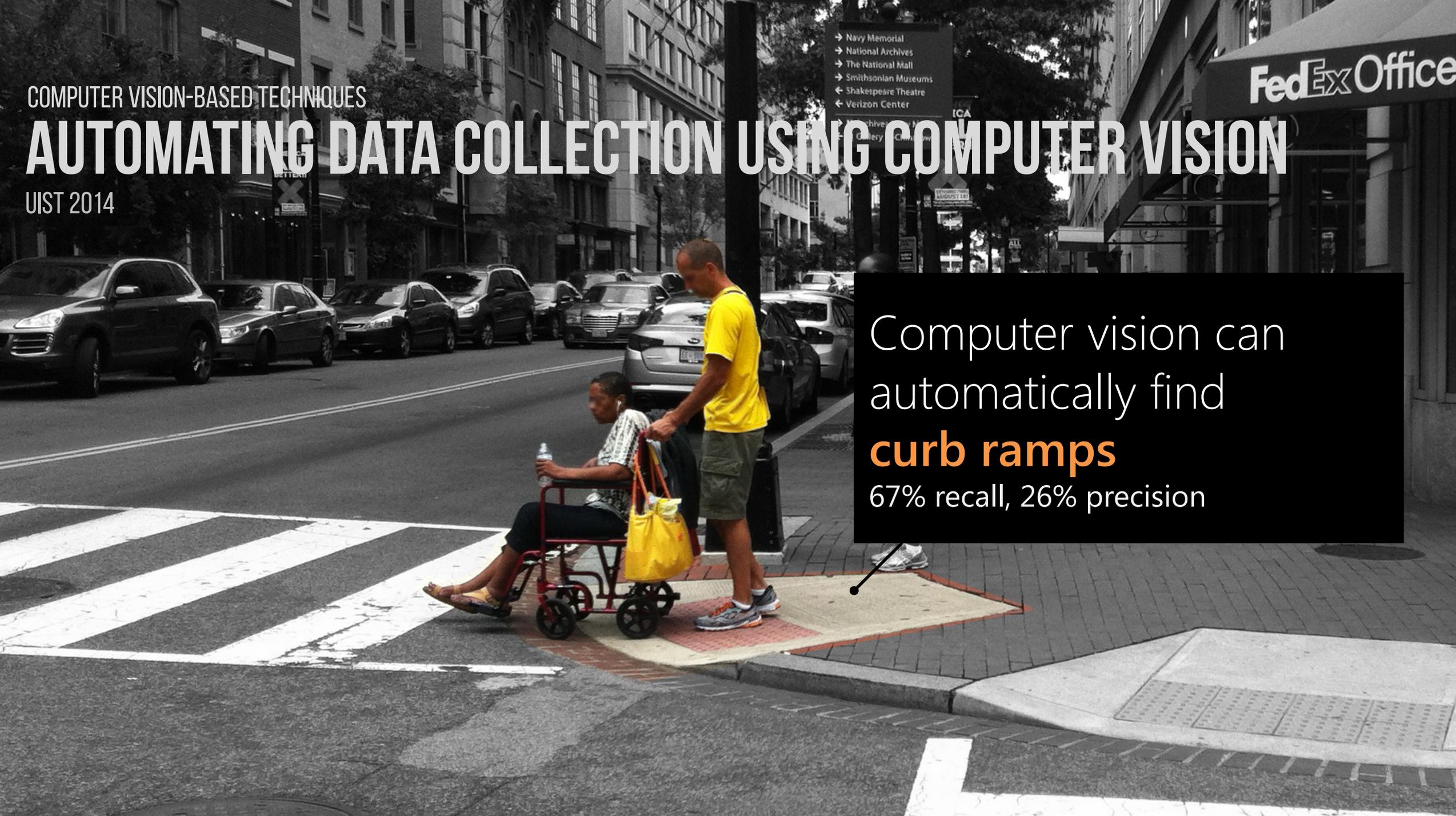
AUTOMATING DATA COLLECTION USING COMPUTER VISION

UIST 2014

- Navy Memorial
- National Archives
- The National Mall
- Smithsonian Museums
- ← Shakespeare Theatre
- ← Verizon Center

Computer vision can automatically find **curb ramps**

67% recall, 26% precision



AUTOMATING DATA COLLECTION USING COMPUTER VISION

CVPR 2017



27% recall

Missing Curb Ramps

Missing Curb Ramp

Curb Ramp

AUTOMATING DATA COLLECTION USING COMPUTER VISION

ASSETS 2019

Curb Ramp



+17% recall

Obstacles



+117% recall



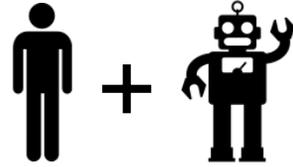
Missing Curb Ramp



Surface Problem



Crowdsourced
Data Collection



(semi) Automated
Data Collection



Accessibility-aware
Application Design



Crowdsourced
Data Collection



Automated
Data Collection

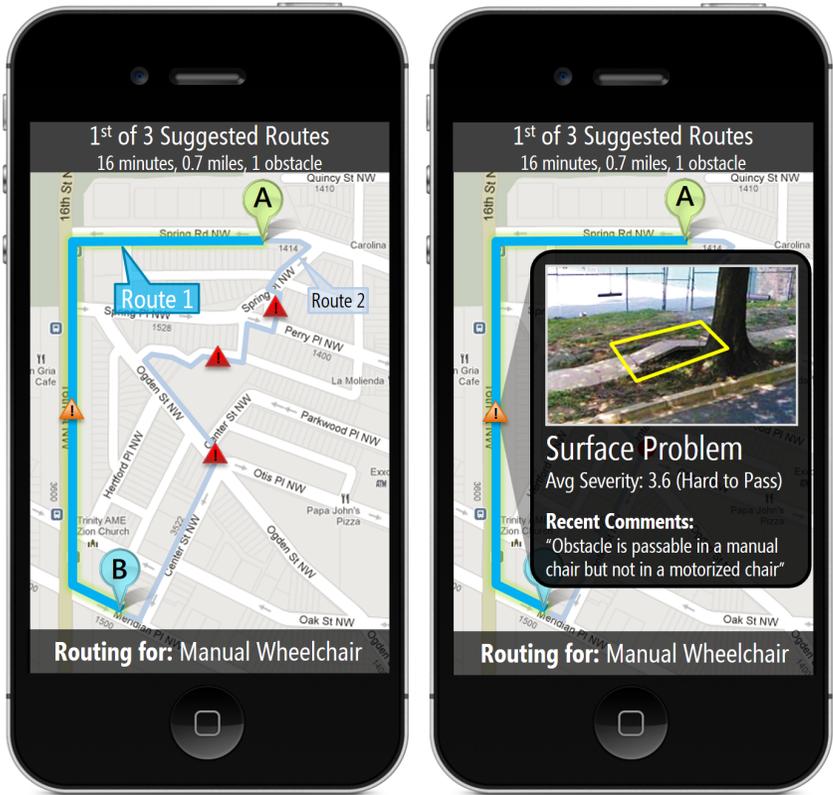


Accessibility-aware
Application Design

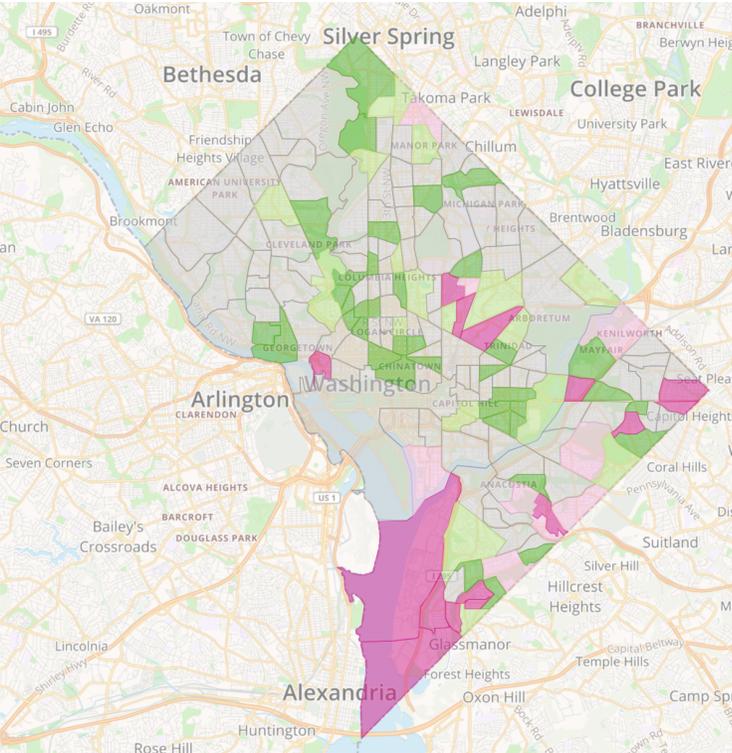


1. What location-based applications should we design with the collected accessibility data?
2. How do we design these interactive mapping tools?

ACCESSIBILITY-AWARE APPLICATIONS



Smart routing for people with mobility impairments

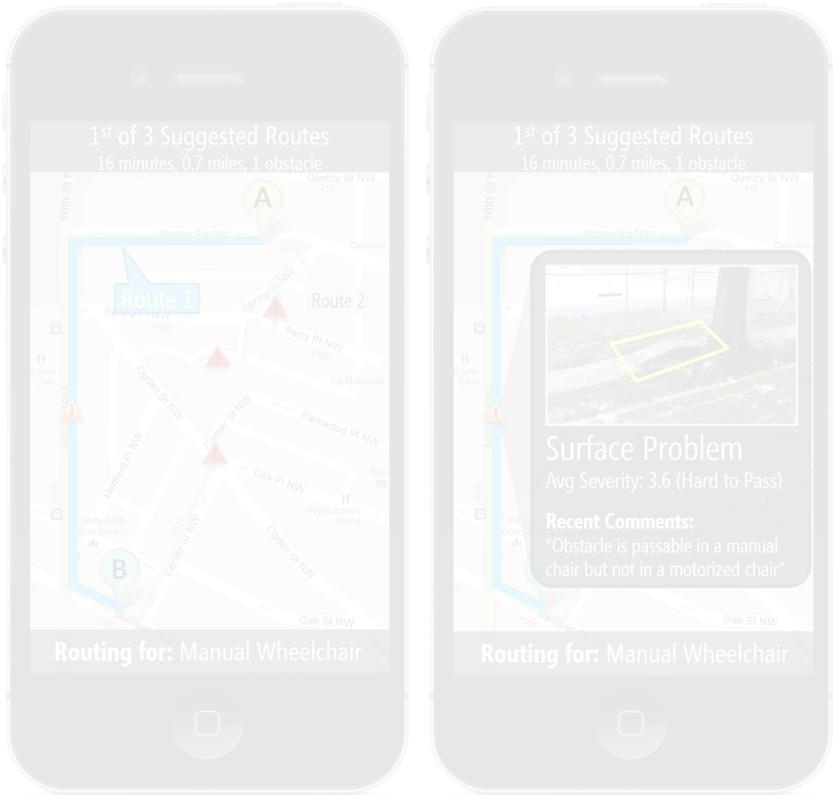


City accessibility visualizations

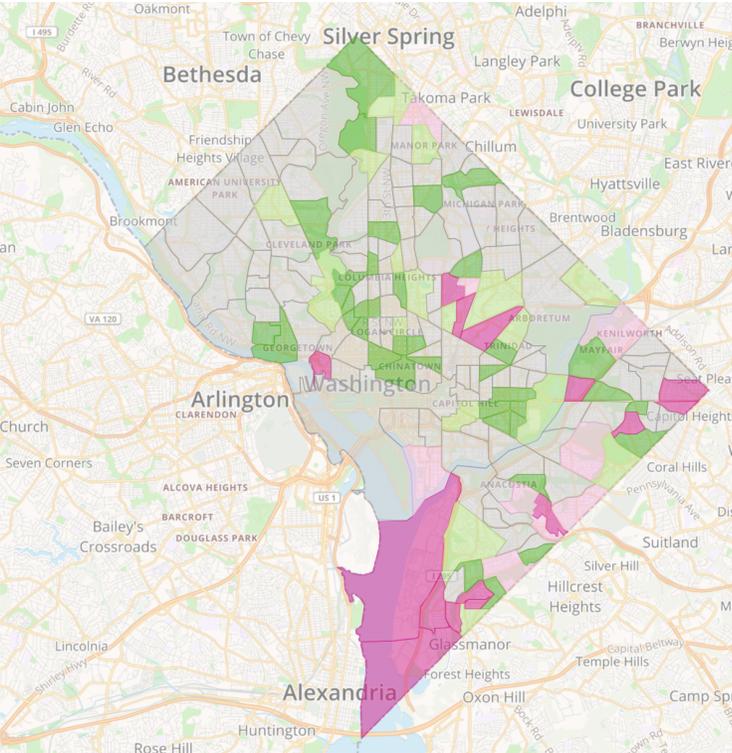
DC
vs
Seattle

Cross-city comparison tools

ACCESSIBILITY-AWARE APPLICATIONS



Smart routing for people with mobility impairments

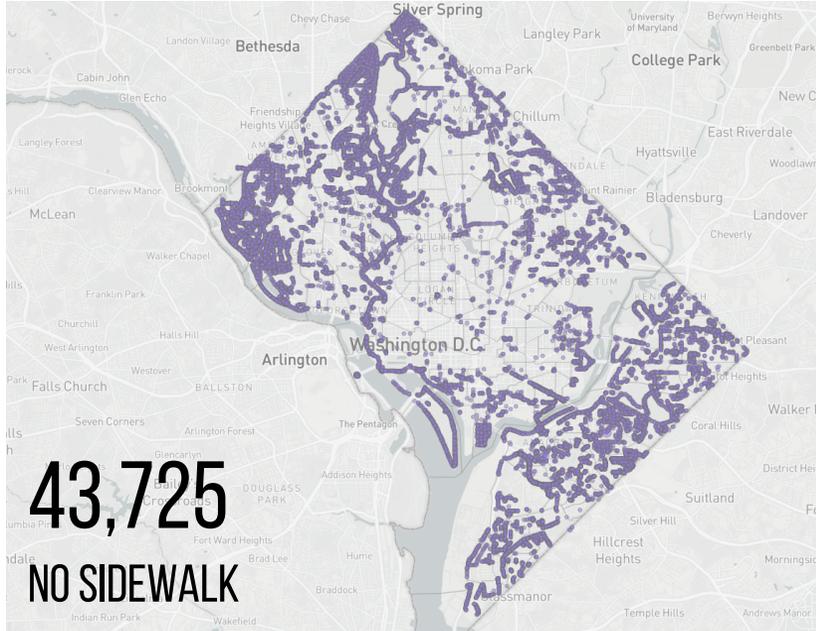
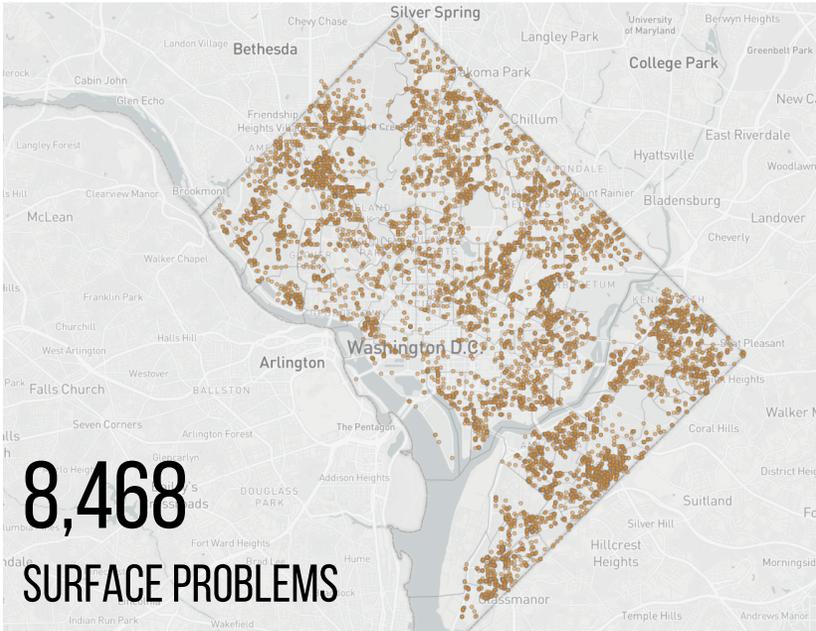
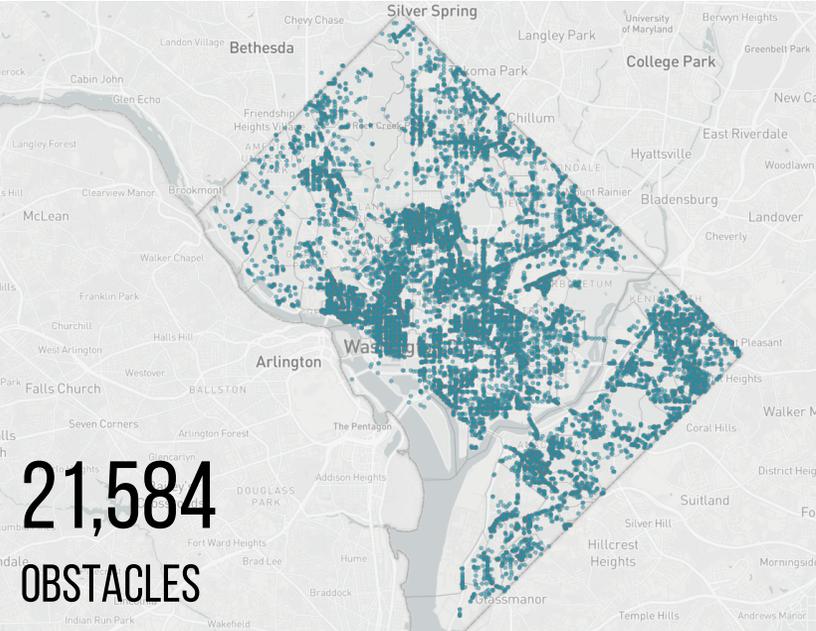


City accessibility visualizations

DC
vs
Seattle

Cross-city comparison tools

VISUALIZING ACCESSIBILITY



What are the **(in)accessible** areas of the city?

Why are they **(in)accessible**?

Where are the areas with **highest repair** needs?

KEY STAKEHOLDERS

What are the (in)accessible areas of the city?



People with Mobility Impairments



Accessibility Advocates



Government Officials

Elected Officials
and other policymakers

DOTs



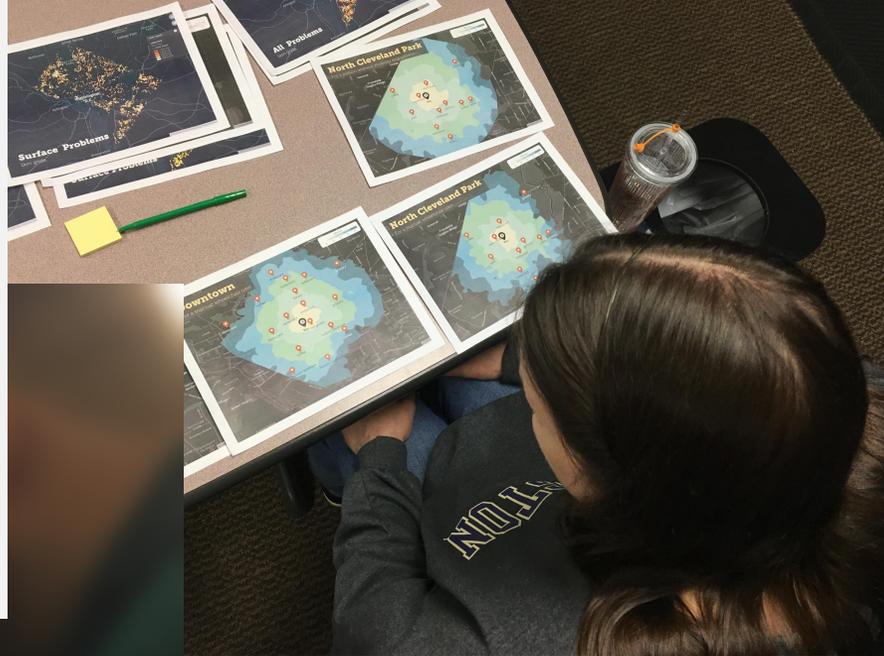
Caregivers

Where are the areas with **highest repair** needs?

DESIGN INTERVIEWS

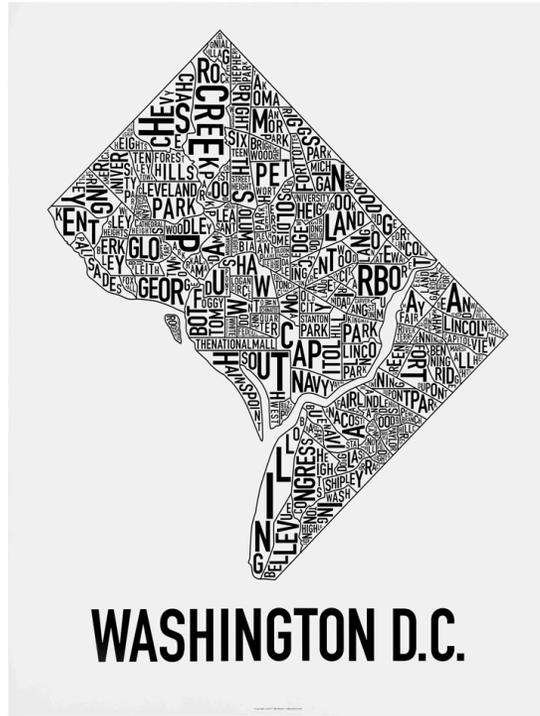
N=25

TRANSPORTATION DEPARTMENT OFFICIALS
CITY ELECTED OFFICIALS
ACCESSIBILITY ADVOCATES
PEOPLE WITH MOBILITY DISABILITIES
CAREGIVERS



WORK IN PROGRESS...

MODELING ACCESSIBILITY



VS



VS



What are the **correlates** to accessibility?
How do we **compare** accessibility across cities?

ACCESS SCORE: PERSONALIZING ACCESSIBILITY MODELS

Interactively Modeling and Visualizing Neighborhood Accessibility at Scale: An Initial Study of Washington DC

Anthony Li¹, Manaswi Saha², Anupam Gupta², Jon E. Froehlich¹
¹University of Maryland, College Park, ²University of Washington, Seattle
antli@umd.edu, {manaswi, anupam, jonf}@cs.washington.edu



Figure 1. In this poster paper, we explore the initial design and implementation of two interactive geo-visualizations of neighborhood accessibility for people with mobility impairments: (a) *AccessScore* and (b) *AccessVisDC*. Both prototypes model and visualize accessibility using Project Sidewalk's API [9].

ABSTRACT
Walkability indices such as walkscore.com model the proximity and density of walkable destinations within a neighborhood. While these metrics have gained widespread use (e.g., incorporated into real-estate tools), they do not integrate accessibility-related features such as sidewalk conditions or curb ramps—thereby excluding a significant portion of the population. In this poster paper, we explore the initial design and implementation of neighborhood accessibility models and visualizations for people with mobility impairments. We are able to overcome previous data availability challenges by using the Project Sidewalk API, which provides access to 255,000+ labels about the accessibility and location of DC sidewalks.

Author Keywords
Urban accessibility; geo-visualization; walkability indices
ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI)

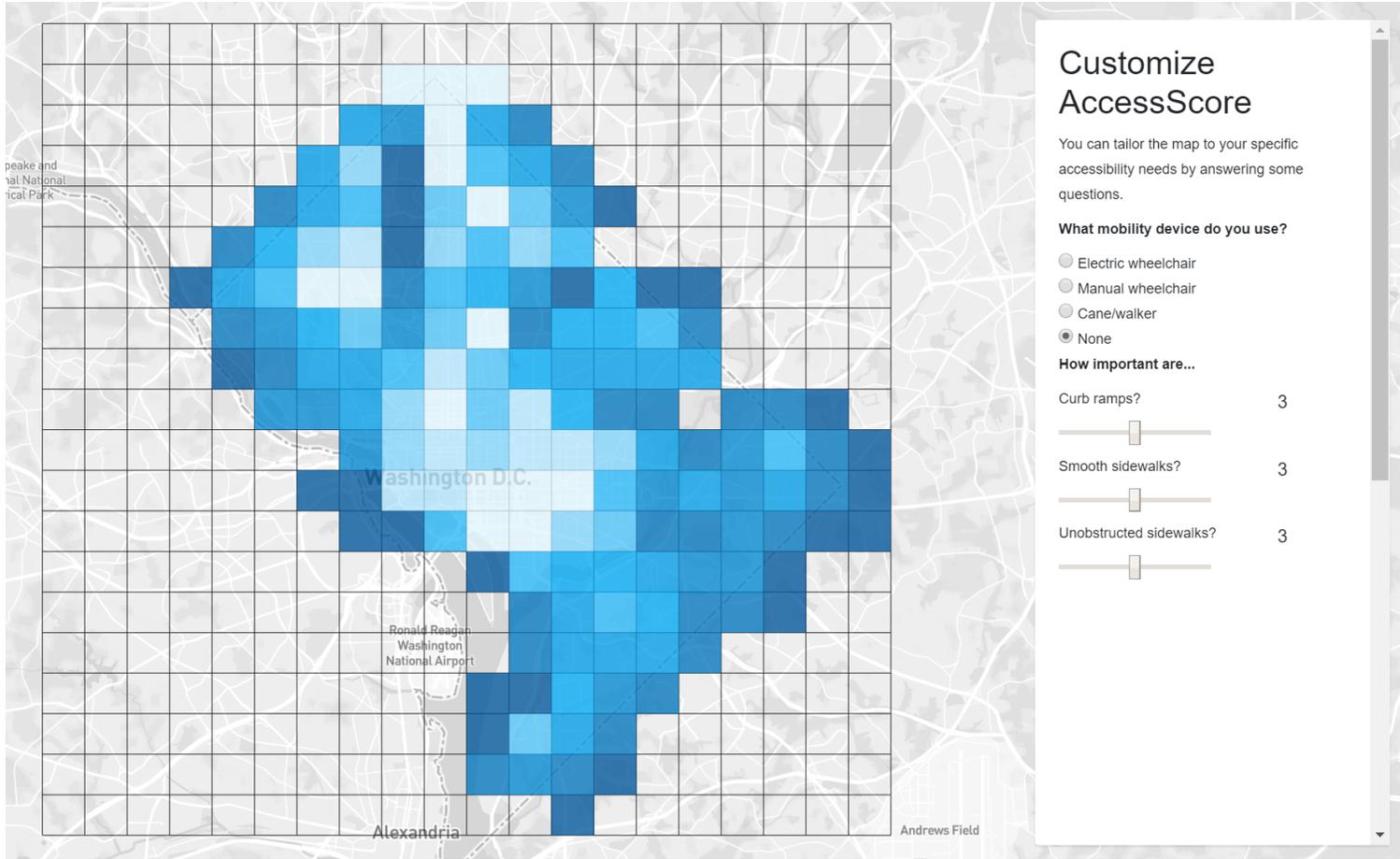
INTRODUCTION
Websites such as walkscore.com model and visualize the “walkability” of neighborhoods by measuring the proximity and density of walkable destinations (e.g., grocery stores, parks, and restaurants). While recent work suggests that neighborhood walkability correlates with real estate value, lower crime rates, and more walking trips for non-work purposes [3, 7], these metrics do not incorporate accessibility-related features such as sidewalk conditions, the presence of curb ramps, and road grade. One key challenge has been data availability.

Enabled by Project Sidewalk's API (projectsidewalk.io/api), which provides access to 255,000+ labels describing the accessibility and location of Washington DC sidewalks [9], we designed and implemented two interactive geo-visualizations of neighborhood accessibility for people with mobility impairments (Figure 1). While recent work has explored accessibility-aware pedestrian routing algorithms and tools [1, 11], these systems are focused on wayfinding rather than modeling and visualizing higher-level abstractions of accessibility. Our aim is complementary: to provide personalizable, interactive, and glanceable visualizations of city-wide accessibility.

As early work, our research questions are exploratory: how can we develop algorithmic models that accurately describe the accessibility of streets and sidewalks? How can we make these models and resulting visualizations parameterizable to meet the needs of different users (e.g., manual vs. electric wheelchair users)? How can we make our visualizations responsive and interactive over the web (even with 100,000+ data points)? To begin addressing these questions, we report on the initial development of two open-source prototype visualization tools: *AccessScore* and *AccessVisDC*.

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ACM ISBN 978-1-4503-5600-3/18/10.
<https://doi.org/10.1145/3234695.3241000>

Source code and live demos for AccessScore: <https://goo.gl/d0MR3G> and AccessVisDC: <https://goo.gl/yb93RZ>.

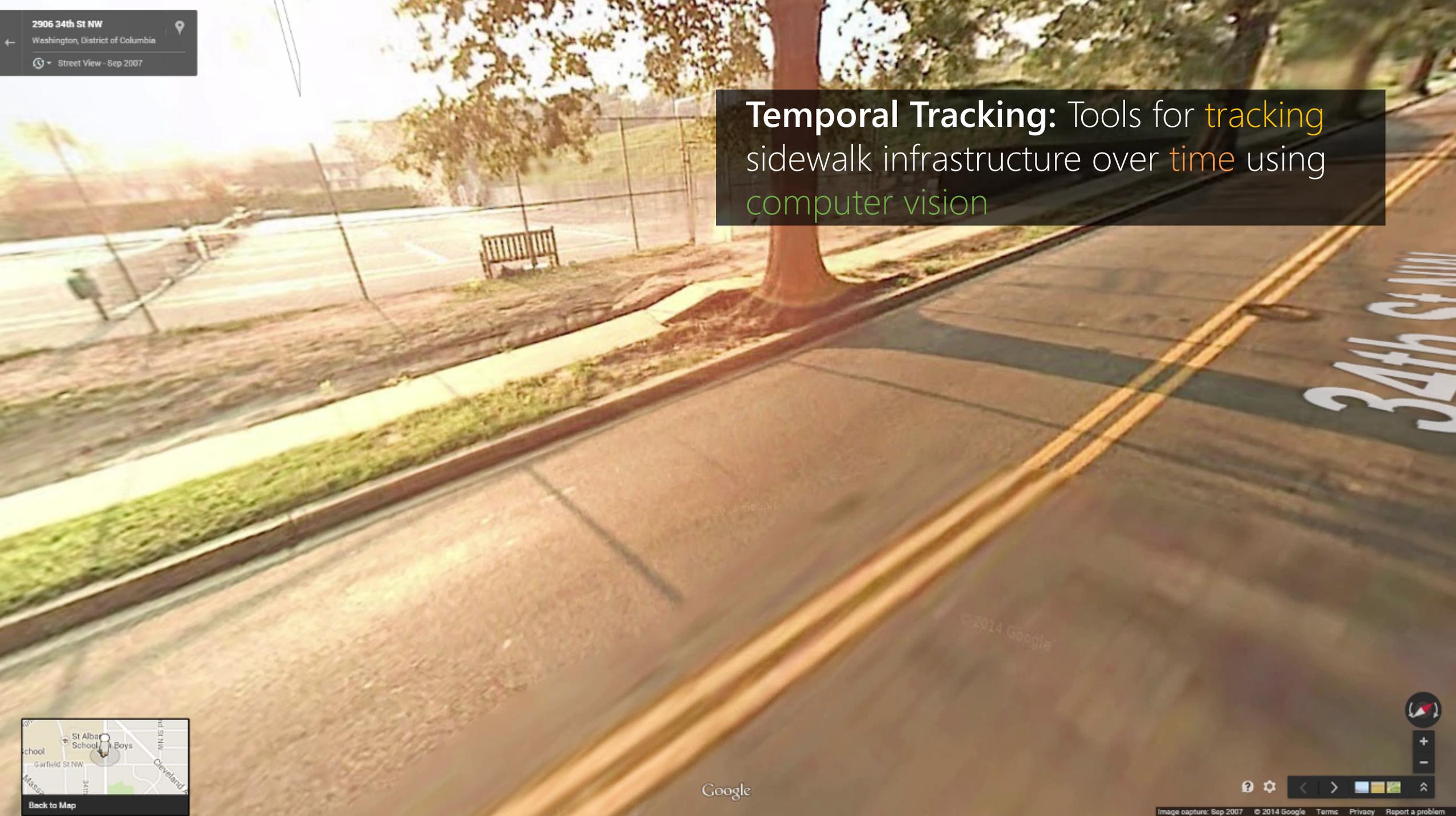


Urban Evolution

How does accessibility change over time?

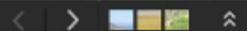
BROADWAY HIT
THE KING & I
NOW TILL MAY 22
LYRICOPERA.ORG

Temporal Tracking: Tools for tracking sidewalk infrastructure over time using computer vision



Back to Map

Google



APPLICATIONS: TEMPORAL TRACKING

TRACKING ACCESSIBILITY INFRASTRUCTURE OVER TIME



Sept 2007



Jul 2009



May 2011



June 2011



May 2014



Aug 2014



Nov 2016

TRACKING ACCESSIBILITY INFRASTRUCTURE OVER TIME

ASSETS 2018

A Feasibility Study of Using Google Street View and Computer Vision to Track the Evolution of Urban Accessibility

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University of Maryland, College Park
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Jon E. Froehlich
University of Washington
jonf@cs.washington.edu



Figure 1. In this paper, we examine the feasibility of using Google Street View's "time machine" feature [4] and basic computer vision algorithms to track changes in urban accessibility over time. For each location, accessibility problems are manually labeled in the most recent Street View image (blue outline) then are automatically back propagated through time (red outlines) to track and discover potential changes. In the example here, an object in the pedestrian path has persisted over time to the most recent data (2014), while a sidewalk surface problem from 2007 was resolved by 2009.

ABSTRACT
Previous work has explored scalable methods to collect data on the accessibility of the built environment by combining manual labeling, computer vision, and online map imagery. In this poster paper, we explore how to extend these methods to track the evolution of urban accessibility over time. Using Google Street View's "time machine" feature, we introduce a three-stage classification framework: (i) manually labeling accessibility problems in one time period; (ii) classifying the labeled image patch into one of five accessibility categories; (iii) localizing the patch in all previous snapshots. Our preliminary results analyzing 1633 Street View images across 376 locations demonstrate feasibility.

Author Keywords
Urban accessibility; computer vision; Google Street View

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI)

INTRODUCTION
Recent work has explored scalable methods to identify and characterize accessibility features in the built environment using remote crowdsourcing, machine learning, and online map datasets (e.g., *Google Street View (GSV)* [5, 7, 11], satellite photographs [1]). For example, *Tolme* [7] combines computer vision with web-based crowd work to semi-automatically label curb ramps in GSV. While accurately finding and assessing accessibility features in map imagery is still an active research area, in this poster paper, we begin to explore a related but even more data-intensive process—how to semi-automatically track the evolution of urban accessibility over time using historical map data (Figure 1). Our work builds on decades of past research in urban studies, geography, and ecology, which analyze temporal changes in

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<https://doi.org/10.1145/3234695.3240999>

land use from remote sensors. Typically, however, the focus is on macroscopic trends (e.g., urbanization [8, 14, 18], deforestation [13]), which do not require the detailed sensing of small entities that our work requires (e.g., light poles, curb ramps). In addition, rather than rely on satellite images, we use the historical omnidirectional panoramic imagery found in GSV's "time machine" [4]. With the emergence of large-scale image sets and an interest in vision algorithms to support autonomous vehicles, computer scientists have also begun to develop techniques to detect and model urban change [2, 9, 12]. Our techniques are informed by these approaches but with a distinct focus on tracking accessibility.

Our contributions include: (i) a preliminary examination of using GSV's "time machine" as a data source for tracking (in)accessible pedestrian infrastructure over time; (ii) an initial three-stage classification framework for labeling and categorizing accessibility features through time; (iii) a preliminary study validating our approach.

FEASIBILITY STUDY
To examine the feasibility of our approach, we created a test dataset, implemented a classification framework, and performed initial validation. Based on [6, 11], we track five classes of sidewalk features: *accessible sidewalks* (i.e., no problems), *accessible curb ramps*, *missing curb ramps*, *objects in path*, and *surface problems*.

Dataset
We built our dataset by randomly selecting locations in Washington DC and Maryland, examining the GSV imagery to identify accessibility features, and then using "time machine" to capture historical panoramas. As we are primarily interested in how accessibility features change over time, we iteratively diversified the dataset to include locations where features: (i) changed over time; (ii) persisted over time; or (iii) were occluded in at least one time period (e.g., by a passing car), making it difficult to track temporal changes. For each location, we captured a screenshot of all available images across time and recorded GPS coordinates, Street View URL, capture timestamp, and the camera's yaw, pitch, and field-of-view.



ACCESSIBILITY IS IMPORTANT



GROWTH

Seattle's got terrible sidewalks. help fix them.

With UW's Project Sidewalk, volunteers look for broken and missing curb ramps that make the city inaccessible with disabilities.

by Josh Cohen / April 26, 2019



A partly repaired sidewalk on Capitol Hill. Broken sidewalks and missing curb ramps make Seattle mobility disabilities. (Dorothy Edwards/Crosscut)

For Vanessa Link, broken concrete and missing curb ramp inconvenience. They're a barrier to her independence. University of Washington student, disability rights advocate and power wheelchair user. She relies on reasonably smooth curb ramps from sidewalk to the street in order to navigate the things are missing — an all-too-common occurrence in Seattle block or more out of her way or get "creative" by seeking out m

SCIENCES

Nov. 30, 2016 9:57 am

How Project Sidewalk is making DC more accessible

With your help, researchers can use computer vision and machine learning to flag accessibility issues across the District.



By Aysha Khan / CONTRIBUTOR



Team Project Sidewalk at work.

(Photo by Aysha Khan)

As public transportation and ridesharing apps swell in popularity, we often talk about how walkable a city is: Can you get to work without a car? Can you walk to a grocery store, hospital and school from your home or office?

In D.C., the answer is often yes. The district has a walkability score of 77, making it by some counts America's seventh most walkable large city.

But of its approximately 1,000 miles, how many are accessible to someone in a wheelchair?

This fall, Jon Froehlich of the University of Maryland's Human-Computer Interaction Lab (HCL) debuted a new tool that can help answer that question.

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About Odessa

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TOP ARTICLES

- 1 NSA goes public with Windows security vulnerability
- 2 Virginia-based Cofense debuted its phishing defense podcast
- 3 Here's what Procurated's founder considered when making his first hire last year



You Can Help Map the Accessibility of the World



JOSH COHEN OCTOBER 3, 2016



As I cross through the intersection of Independence Ave and 19th Street in Washington, D.C.'s Hill East neighborhood, I make note of four high-quality curb ramps coming off the sidewalks and into the streets. Making my way past the D.C. Armory, I keep my eyes peeled for cracks in the sidewalk and pavement warped by tree roots, but this appears to be a pretty well-maintained stretch. I spot a few more curb ramps and note they're narrower than the previous bunch and perhaps not up to code. One driveway crossing is built at sidewalk height, but the asphalt touching the sidewalk is starting to crack, creating a little gap that could pose a problem.

ACKNOWLEDGEMENTS

PROJECT SIDEWALK TEAM



Manaswi Saha



Michael Saugstad



Galen Weld



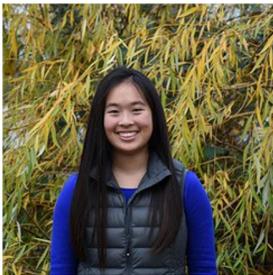
Ather Sharif



Hanuma Teja Maddali



Jon Froehlich



Aileen Zeng



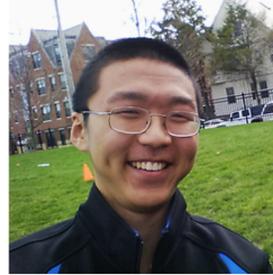
Hank Tadeusaik



Tim Nguyen



Marianne Aubin
Le Quéré



Anthony Li



Steven Bower



Ryan Holland



Aditya Dash



Sage Chen

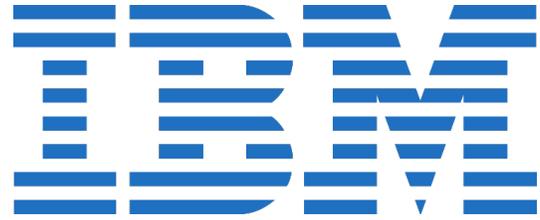


Kotaro Hara

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NSF #1302338, Google, IBM
PI Froehlich, Co-PI David Jacobs



Project Sidewalk: Mapping the Accessibility of the Physical World **at Scale** using Interactive Computational Tools

Manaswi Saha

PhD Student | Computer Science | University of Washington

Any Questions?



Help make the world more **accessible** for everyone!

Join us. Contact  manaswi@cs.uw.edu  [manaswisaha](https://twitter.com/manaswisaha)

 <https://github.com/ProjectSidewalk>  <http://projectsidewalk.io/api>



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