CROWD + AI TOOLS FOR SCALABLE SIDEWALK ASSESSMENT

Jon E. Froehlich
University of Washington

Spatial Data Science Symposium
Dec 13, 2021

DESIGN USE BUILD · MAKEABILITY LAB · CREATE · PAUL G. ALLEN SCHOOL OF COMPUTER SCIENCE & ENGINEERING · UNIVERSITY of WASHINGTON

ABOUT ME

Back to UW in 2017 as a CS Prof!

Minnesota
Childhood

Computer Engineering
Bachelors

Information & Computer Science
Masters

Computer Science
PhD

Computer Science
Professor (2012-2017)

Voting with Your Feet: An Investigative Study of the Relationship Between Place Visit Behavior and Preference*

Jon Froehlich[1], Mike Y. Chen[2], Ian E. Smith[2], and Fred Potter[1]

[1] Department of Computer Science and Engineering, University of Washington, Seattle, WA, USA
[2] Intel Research, Seattle, WA, USA

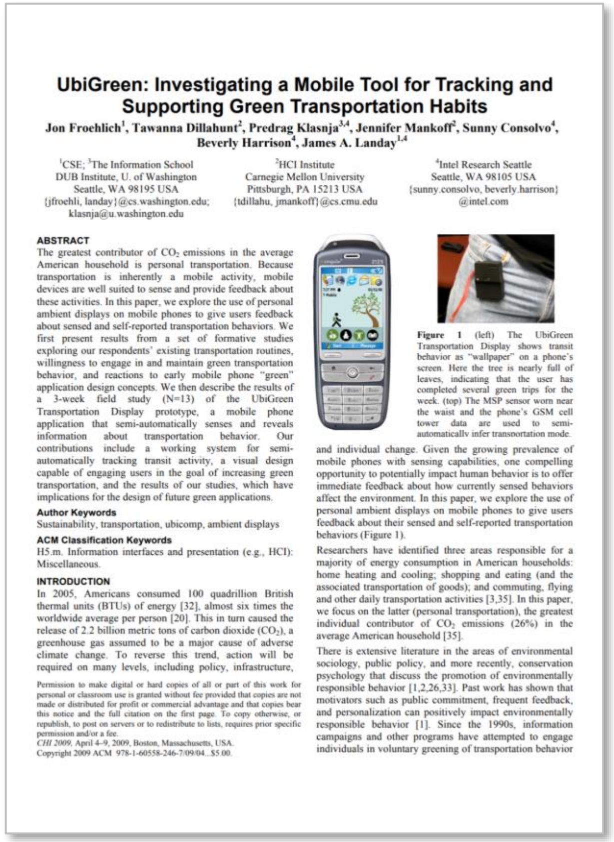
UbiComp'06

2008-01-0201

Route Prediction from Trip Observations

John Froehlich, University of Washington
John Krumm, Microsoft Research

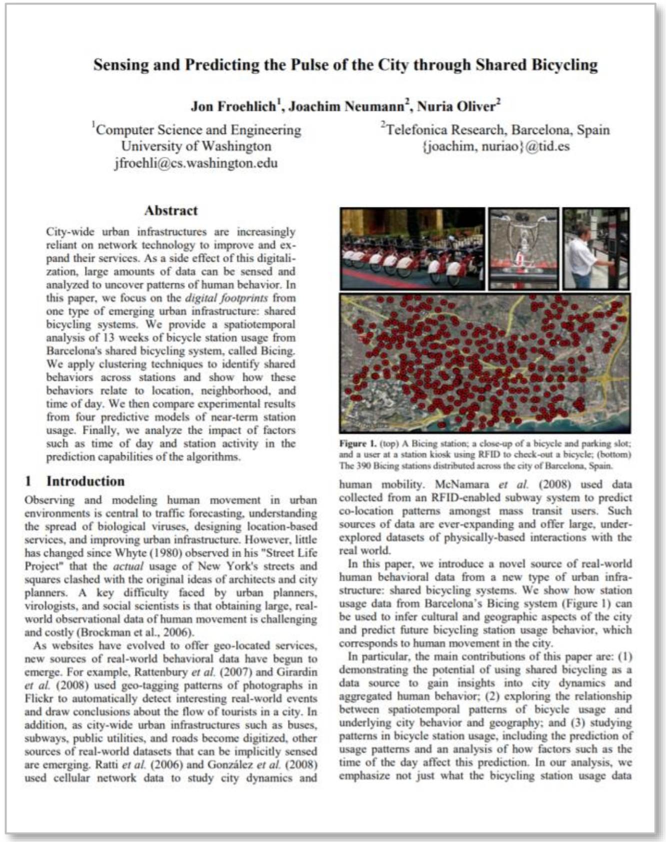
SAE'08



UbiGreen: Investigating a Mobile Tool for Tracking and Supporting Green Transportation Habits

Jon Froehlich[1], Tawanna Dillahunt[2], Predrag Klasnja[3,4], Jennifer Mankoff[2], Sunny Consolvo[4], Beverly Harrison[4], James A. Landay[1,4]

CHI'09



Sensing and Predicting the Pulse of the City through Shared Bicycling

Jon Froehlich[1], Joachim Neumann[2], Nuria Oliver[2]

[1] Computer Science and Engineering, University of Washington
[2] Telefonica Research, Barcelona, Spain

IJCAI'09

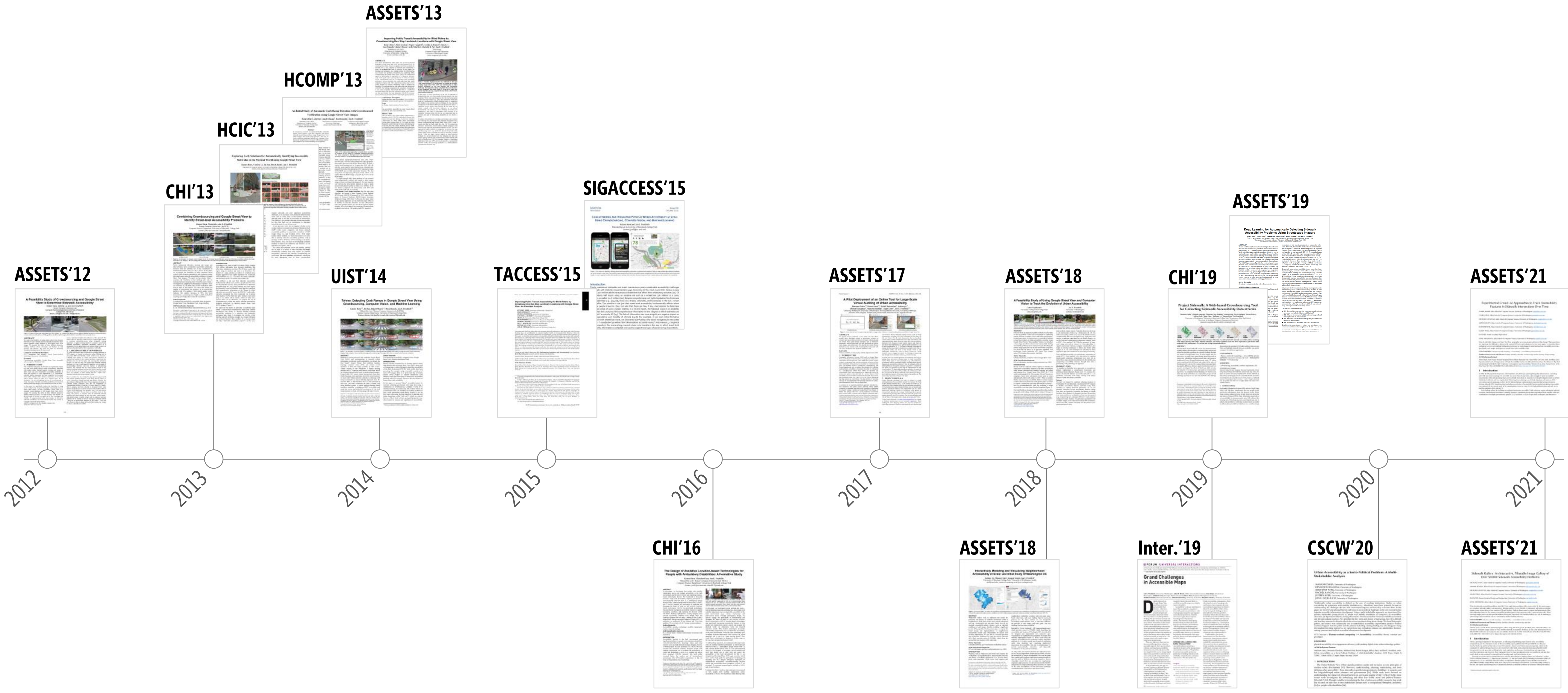

MAKEABILITY LAB
2019 Retreat
MAKEABILITY LAB

The National Council on Disability notes 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 OVERARCHING VISION

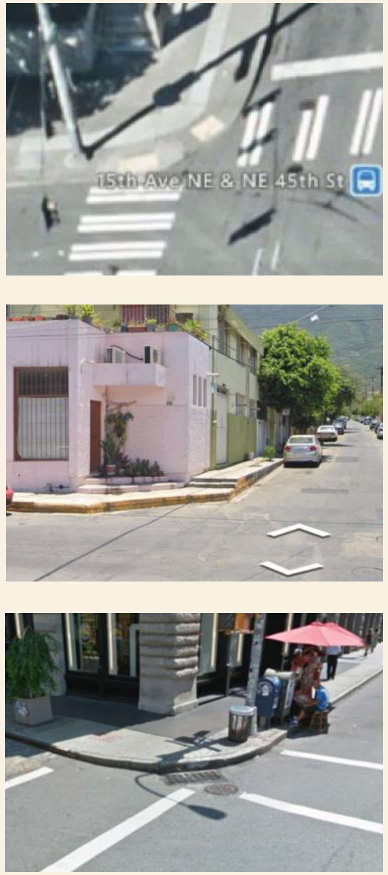
Develop crowd+AI techniques to map and assess every sidewalk in the world


ASSETS'13
HCOMP'13
HCIC'13
CHI'13
SIGACCESS'15
ASSETS'19
ASSETS'12
UIST'14
TACCESS'15
ASSETS'17
ASSETS'18
CHI'19
ASSETS'21
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
CHI'16
ASSETS'18
Inter.'19
CSCW'20
ASSETS'21

PROJECT SIDEWALK

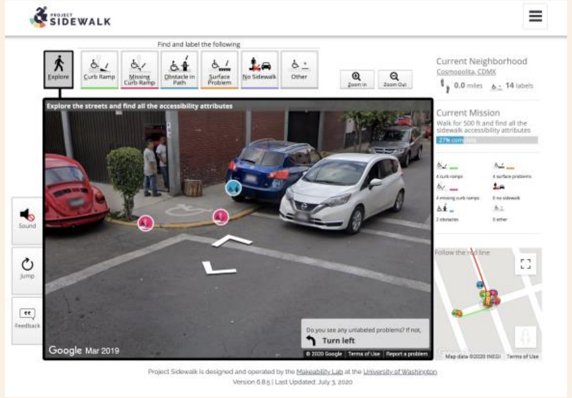
http://projectsidewalk.org

ONLINE MAP IMAGERY

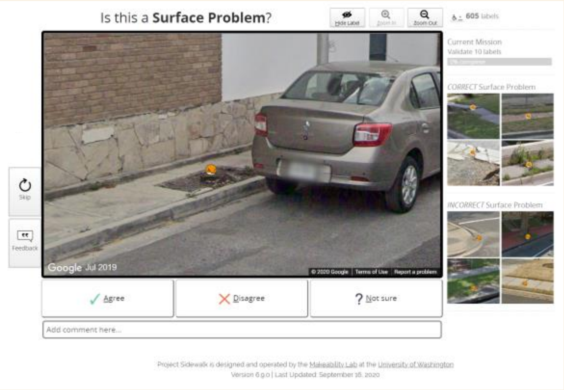


+

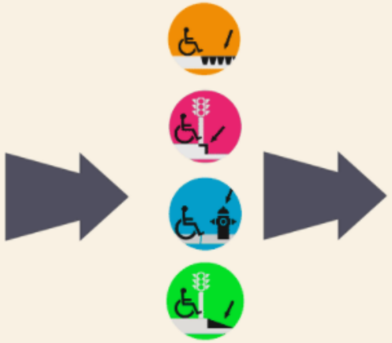
REMOTE CROWDSOURCING INTERFACES



Labeling missions



Validation missions



HUMAN LABELS

MACHINE LEARNING

PROJECT SIDEWALK
HTTP://PROJECTSIDEWALK.IO

PROJECT

SIDEWALK

HTTP://PROJECTSIDEWALK.IO

PROJECT SIDEWALK

REMOTE CROWDSOURCING

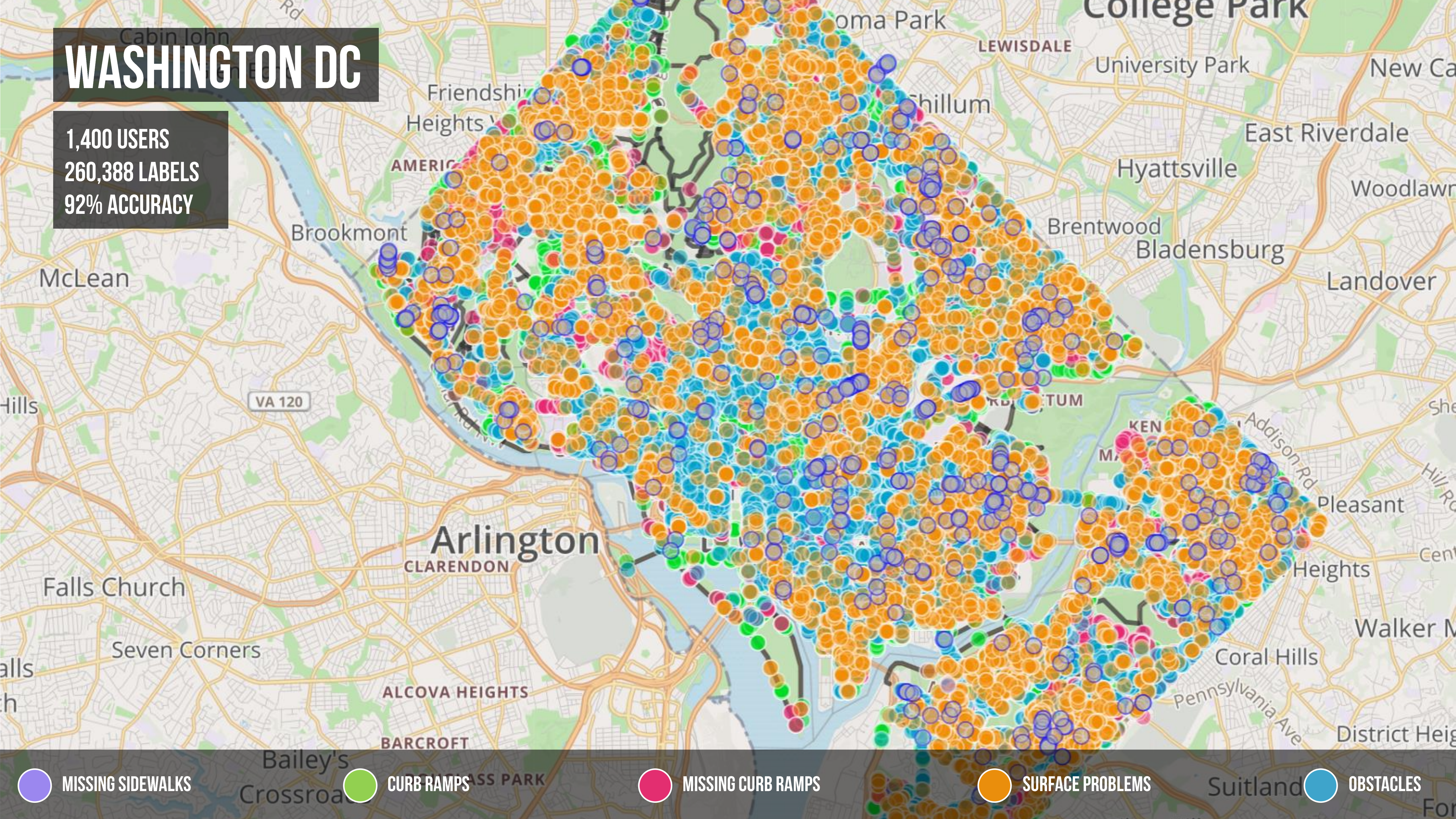
LABELING MEXICO CITY FROM GERMANY!

Source: Edgar Martínez, Liga Peatonal

PILOT DEPLOYMENT IN 2017

Washington DC

PROJECT SIDEWALK


WASHINGTON DC
1,400 USERS
260,388 LABELS
92% ACCURACY
MISSING SIDEWALKS
CURB RAMPS
MISSING CURB RAMPS
SURFACE PROBLEMS
OBSTACLES
Arlington
CLARENDON
McLean
Falls Church
Seven Corners
ALCOVA HEIGHTS
BARCROFT
Brookmont
VA 120
Hyattsville
East Riverdale
University Park
LEWISDALE
Brentwood
Bladensburg
Landover
Woodlawn
Coral Hills
Pleasant
Heights
Walker
District Heig
Suitland
Pennsylvania Ave
Addison Rd
Bailey's
Crossroa
College Park


Seattle, WA
Newberg, OR
Chicago, IL
Pittsburgh, PA
Columbus, OH
Washington DC
San Pedro Garza García, MX
Mexico City, MX
PROJECT SIDEWALK

GROWING DATA

10,000+
USERS

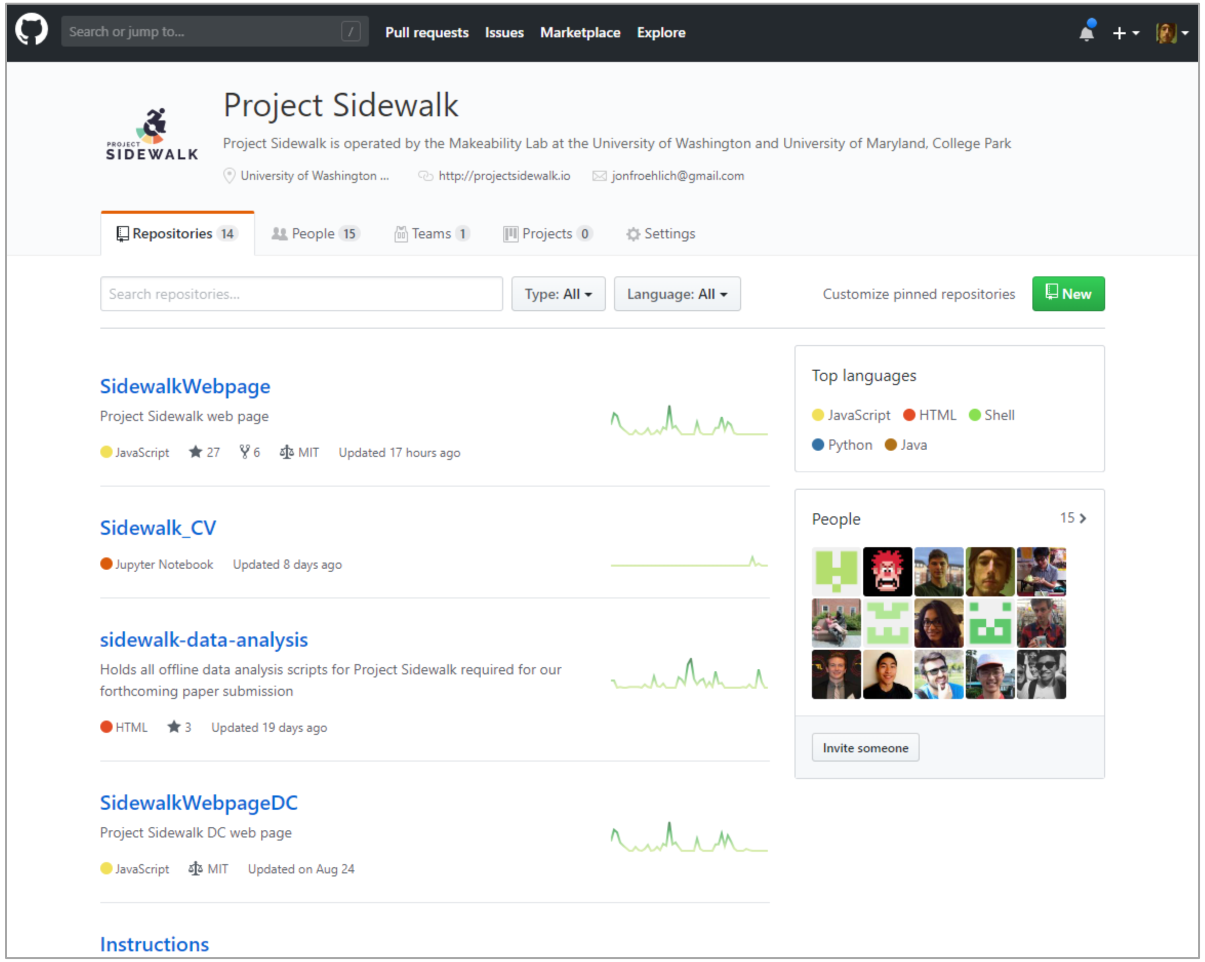
650,000
LABELS

235,000
VALIDATIONS

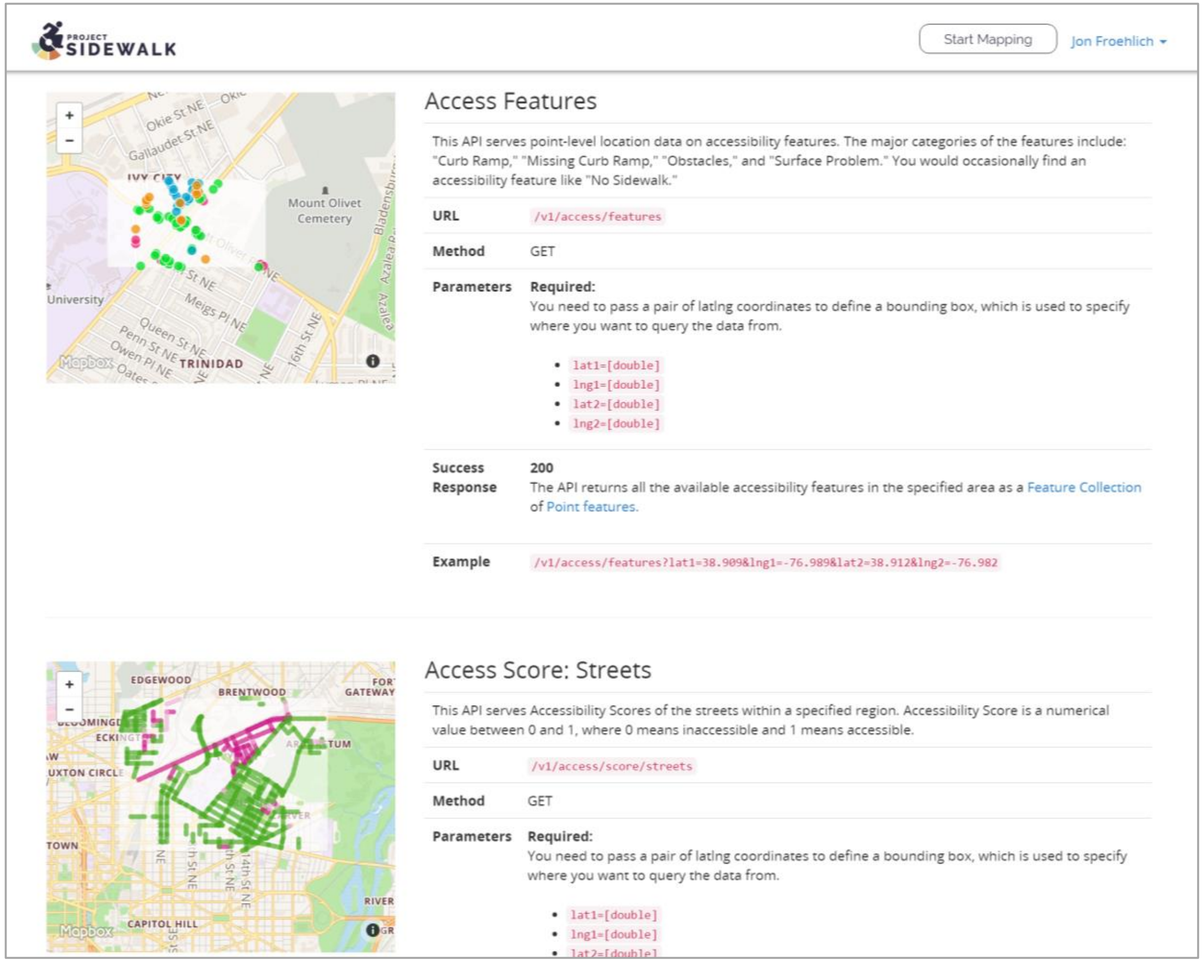
PROJECT SIDEWALK

PROJECT SIDEWALK

ALL OUR CODE + DATA IS 100% OPEN SOURCE



https://github.com/ProjectSidewalk



http://projectsidewalk.io/api

QUESTIONS

How can we combine crowds + AI in new ways to improve sidewalk labeling efficacy and quality?

How can these emerging, cross-city datasets enable new urban science research and advocacy tools?

How is urban accessibility changing and where is it not?

Source: @ericleeclark

Deep Learning for Automatically Detecting Sidewalk Accessibility Problems Using Streetscape Imagery

Galen Weld[1], Esther Jang[1], Anthony Li[2], Aileen Zeng[1], Kurtis Heimerl[1], and Jon E. Froehlich[1]
[1]Paul G. Allen School of Computer Science and Engineering, University of Washington, Seattle, USA
[2]Department of Computer Science, University of Maryland, College Park, USA
{gweld, infrared, aileenz, kheimerl, jonf}@cs.washington.edu, antli@umd.edu

ABSTRACT
Recent work has applied machine learning methods to automatically find and/or assess pedestrian infrastructure in online map imagery (*e.g.,* satellite photos, streetscape panoramas). While promising, these methods have been limited by two interrelated issues: small training sets and the choice of machine learning model. In this paper, aided by the recently released Project Sidewalk dataset of 300,000+ image-based sidewalk accessibility labels, we present the first examination of deep learning to automatically assess sidewalks in Google Street View (GSV) panoramas. Specifically, we investigate two application areas: automatically *validating* crowdsourced labels and automatically *labeling* sidewalk accessibility issues. For both tasks, we introduce and use a residual neural network (ResNet) modified to support both image and non-image (contextual) features (*e.g.,* geography). We present an analysis of performance, the effect of our non-image features and training set size, and cross-city generalizability. Our results significantly improve on prior automated methods and, in some cases, meet or exceed human labeling performance.

Author Keywords
Neural networks, accessibility, sidewalks, computer vision

ACM Classification Keywords

inspections by city transit departments or community volunteers. However, these audits are expensive, labor intensive, and infrequent. [1] Moreover, the resulting data is in disparate formats, is not typically open (*i.e.,* published online), and is not intended for end-user tools [23, 50]. To expand who can collect sidewalk data and to improve data granularity and freshness, researchers have introduced smartphone-based tools [15, 46, 52] as well as instrumented wheelchairs [35, 39, 51, 57], both of which capture sidewalk information *in situ* as it's experienced. However, these tools have been limited by low adoption, small geographic coverage, and high user burden (*e.g.,* requiring users to take out their phones, load an app, take a picture, annotate it, and upload it) [20, 23].

To partially address these scalability issues, researchers have begun developing automated methods for sidewalk assessment using machine learning and online imagery (*e.g.,* satellite photos [10, 8], panoramic streetscape imagery [31, 32, 59]). While still early, these complementary approaches promise to dramatically decrease manual labor and cost. However, they have been limited by two interrelated issues: small training sets and the choice in machine learning model—both of which negatively impact performance. In this paper, we attempt to address both of these issues.

We present the first examination of deep learning methods to

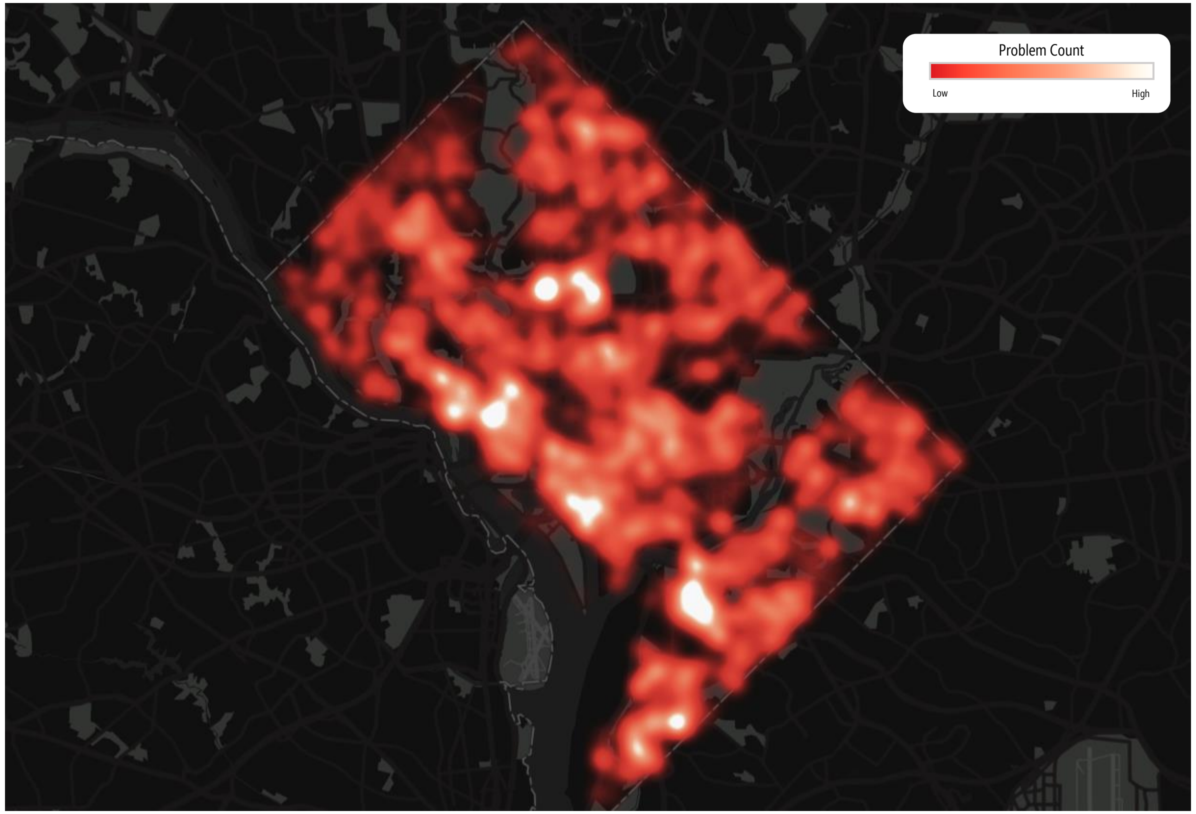
QUESTIONS

How can we combine crowds + AI in new ways to improve sidewalk labeling efficacy and quality?

How can these emerging, cross-city datasets enable new urban science research and advocacy tools?

How is urban accessibility changing and where is it not?

SUPPORT NEW URBAN SCIENCE EXPLORATIONS

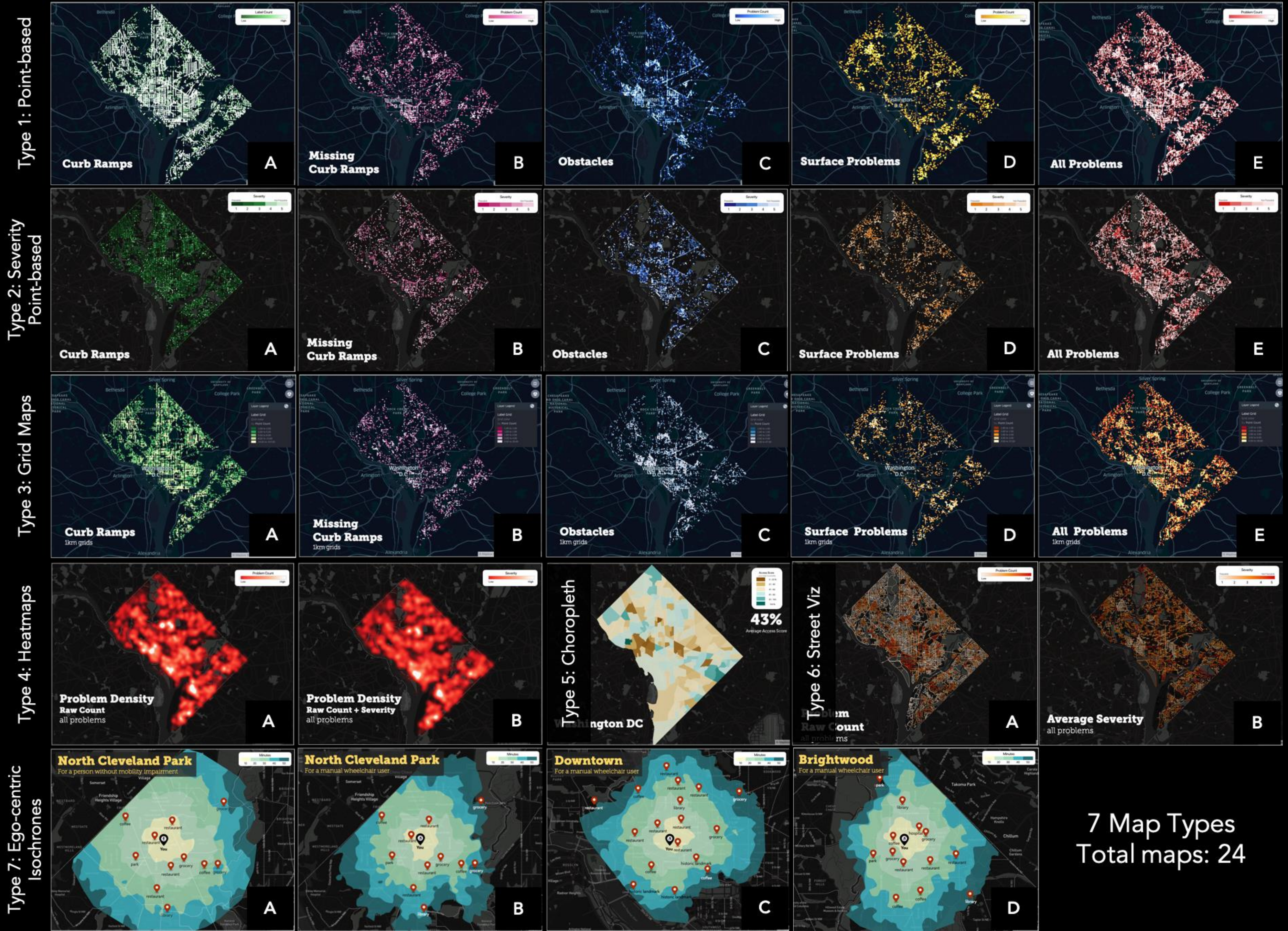


What are the geo-spatial patterns and key correlates of sidewalk accessibility?

How does accessible infrastructure correspond to racial and socio-economic factors? How do these patterns compare across cities?

What do sidewalks look like across cities and countries? How does accessibility vary and why?

How does sidewalk accessibility reflect the socio-cultural and-political context of that region?


Type 1: Point-based
Curb Ramps
A
Missing
Curb Ramps
B
Obstacles
C
Surface Problems
D
All Problems
E
Type 2: Severity
Point-based
Curb Ramps
A
Missing
Curb Ramps
B
Obstacles
C
Surface Problems
D
All Problems
E
Type 3: Grid Maps
Curb Ramps
1km grids
A
Missing
Curb Ramps
1km grids
B
Obstacles
1km grids
C
Surface Problems
1km grids
D
All Problems
1km grids
E
Type 4: Heatmaps
Problem Density
Raw Count
all problems
A
Problem Density
Raw Count + Severity
all problems
B
Type 5: Choropleth
43%
Average Access Score
Washington DC
Type 6: Street Viz
Problem
Raw Count
all problems
A
Average Severity
all problems
B
Type 7: Ego-centric
Isochrones
North Cleveland Park
For a person without mobility impairment
A
North Cleveland Park
For a manual wheelchair user
B
Downtown
For a manual wheelchair user
C
Brightwood
For a manual wheelchair user
D
7 Map Types
Total maps: 24

QUESTIONS

How can we combine crowds + AI in new ways to improve sidewalk labeling efficacy and quality?

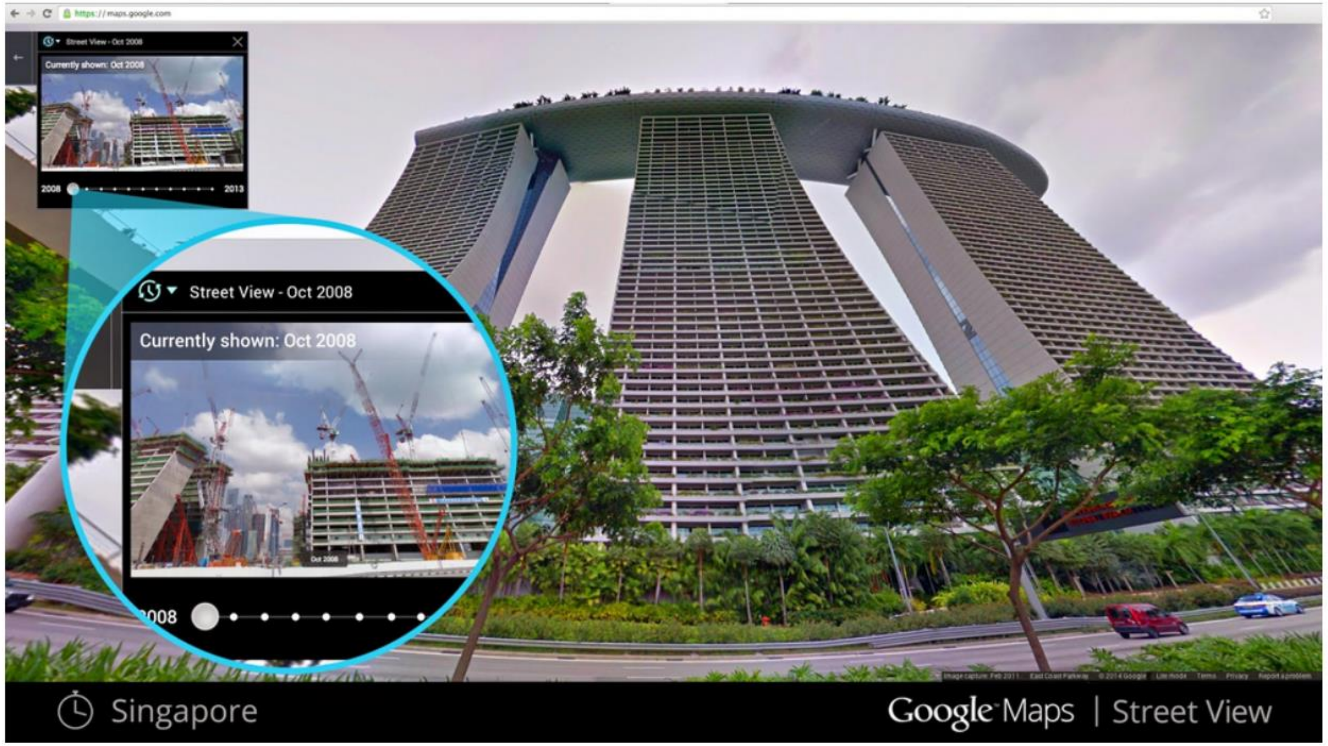
How can these emerging, cross-city datasets enable new urban science research and advocacy tools?

How is urban accessibility changing and where is it not?

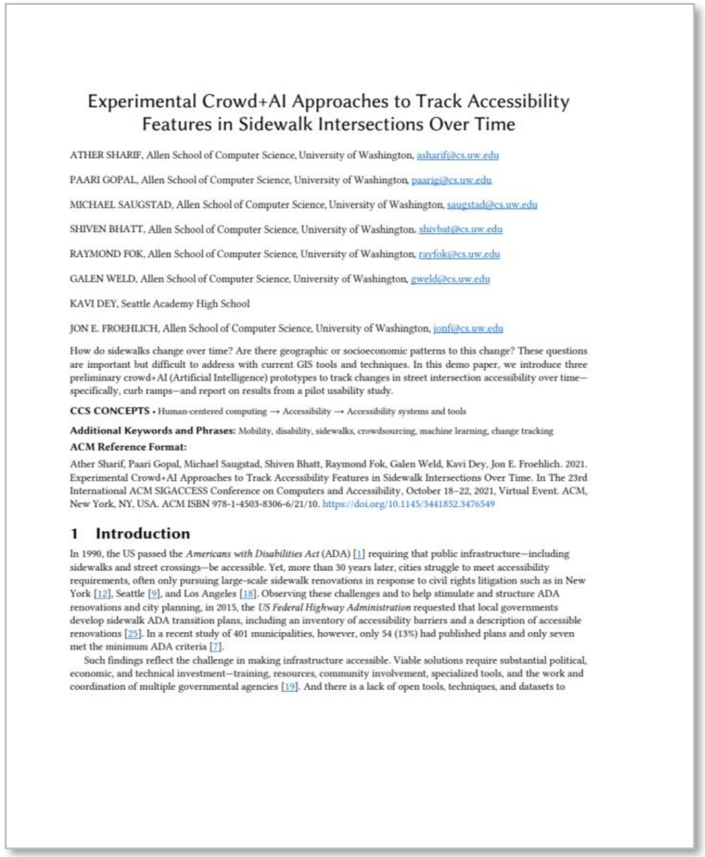
Go back in time with Street View

V
Vinay Shet
Google Street View Product Manager
Apr 23, 2014 · 1 min read

Share



If you see a clock icon in the upper left-hand portion of a Street View image, click on it and move the slider through time and select a thumbnail to see that same place in previous years or seasons.


Experimental Crowd+AI Approaches to Track Accessibility Features in Sidewalk Intersections Over Time

ATHER SHARIF, Allen School of Computer Science, University of Washington, asharif@cs.uw.edu

PAARI GOPAL, Allen School of Computer Science, University of Washington, paarig@cs.uw.edu

MICHAEL SAUGSTAD, Allen School of Computer Science, University of Washington, saugstad@cs.uw.edu

SHIVEN BHATT, Allen School of Computer Science, University of Washington, shivbat@cs.uw.edu

RAYMOND FOK, Allen School of Computer Science, University of Washington, rayfok@cs.uw.edu

GALEN WELD, Allen School of Computer Science, University of Washington, gweld@cs.uw.edu

KAVI DEY, Seattle Academy High School

JON E. FROEHLICH, Allen School of Computer Science, University of Washington, jonf@cs.uw.edu

How do sidewalks change over time? Are there geographic or socioeconomic patterns to this change? These questions are important but difficult to address with current GIS tools and techniques. In this demo paper, we introduce three preliminary crowd+AI (Artificial Intelligence) prototypes to track changes in street intersection accessibility over time—specifically, curb ramps—and report on results from a pilot usability study.

CCS CONCEPTS • Human-centered computing → Accessibility → Accessibility systems and tools

Additional Keywords and Phrases: Mobility, disability, sidewalks, crowdsourcing, machine learning, change tracking

ACM Reference Format:

Ather Sharif, Paari Gopal, Michael Saugstad, Shiven Bhatt, Raymond Fok, Galen Weld, Kavi Dey, Jon E. Froehlich. 2021. Experimental Crowd+AI Approaches to Track Accessibility Features in Sidewalk Intersections Over Time. In The 23rd International ACM SIGACCESS Conference on Computers and Accessibility, October 18–22, 2021, Virtual Event. ACM, New York, NY, USA. ACM ISBN 978-1-4503-8306-6/21/10. https://doi.org/10.1145/3441852.3476549

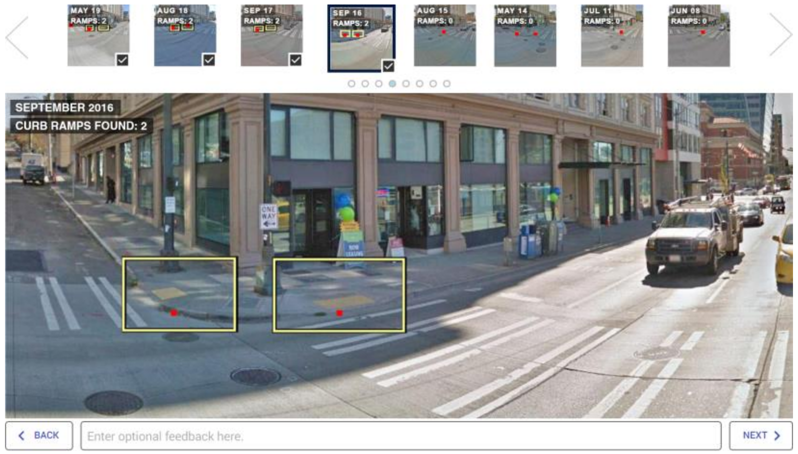
1 Introduction

In 1990, the US passed the *Americans with Disabilities Act* (ADA) [1] requiring that public infrastructure—including sidewalks and street crossings—be accessible. Yet, more than 30 years later, cities struggle to meet accessibility requirements, often only pursuing large-scale sidewalk renovations in response to civil rights litigation such as in New York [12], Seattle [9], and Los Angeles [18]. Observing these challenges and to help stimulate and structure ADA renovations and city planning, in 2015, the *US Federal Highway Administration* requested that local governments develop sidewalk ADA transition plans, including an inventory of accessibility barriers and a description of accessible renovations [25]. In a recent study of 401 municipalities, however, only 54 (13%) had published plans and only seven met the minimum ADA criteria [7].

Such findings reflect the challenge in making infrastructure accessible. Viable solutions require substantial political, economic, and technical investment—training, resources, community involvement, specialized tools, and the work and coordination of multiple governmental agencies [19]. And there is a lack of open tools, techniques, and datasets to

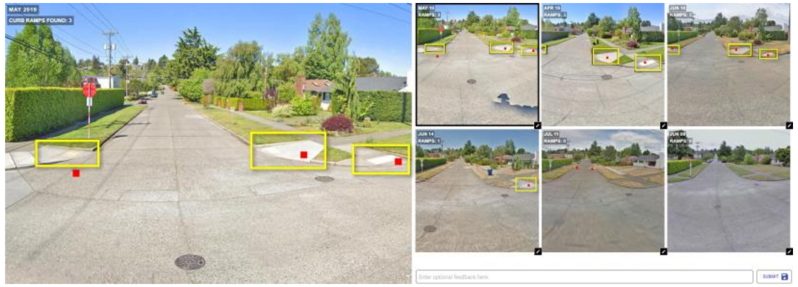
Prototype 1

Single View



Prototype 2

Grid View



Prototype 3

Panorama View

THANK YOU!

Jon E. Froehlich | jonf@cs.uw.edu

Visit http://projectsidewalk.org/