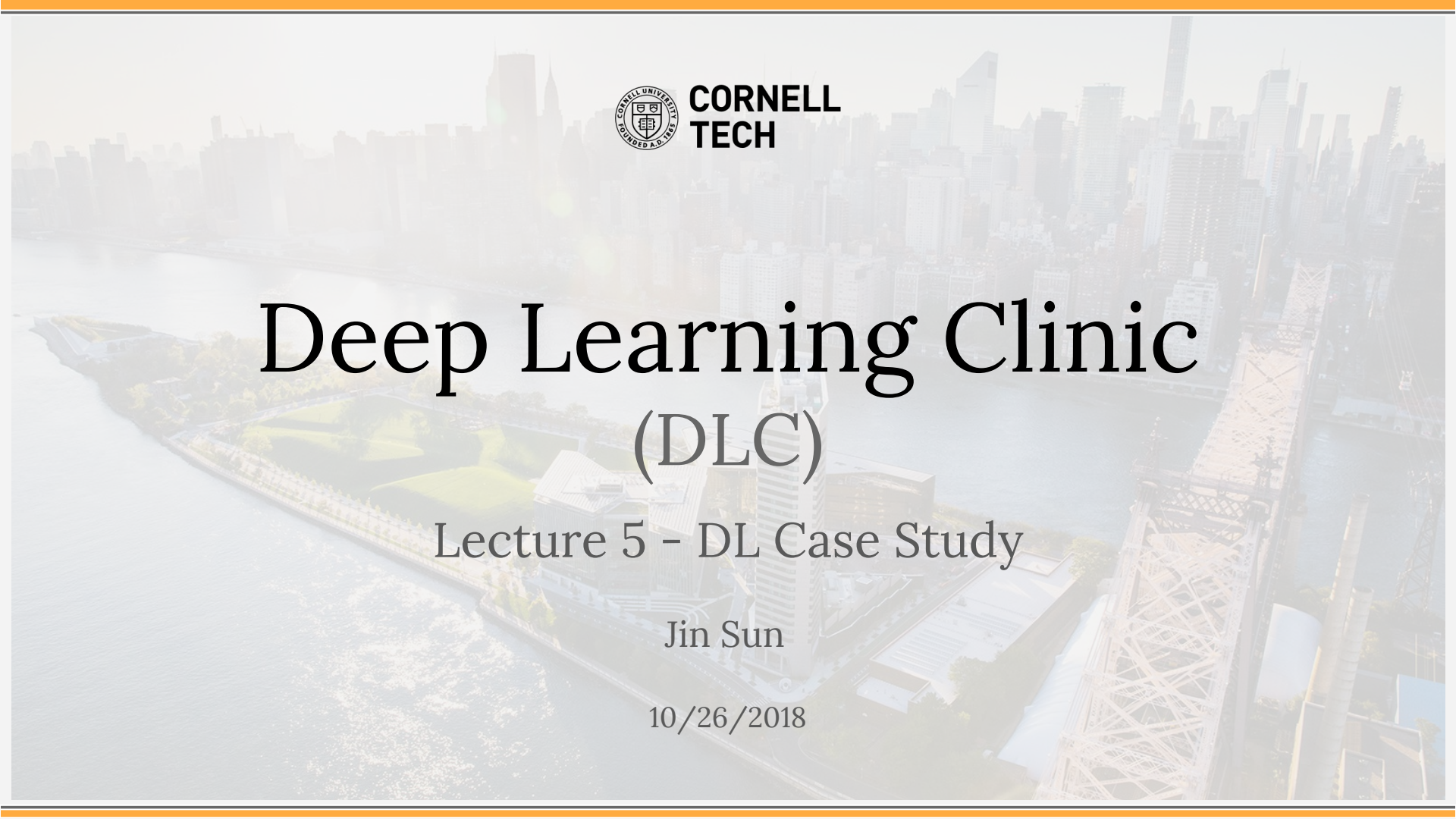


CORNELL TECH

Deep Learning Clinic (DLC)

Lecture 5 - DL Case Study

Jin Sun

10/26/2018

Solving Real World Problems Using ML/DL

- Identify A Real World Problem
- Formulate A Concrete ML/DL Problem
- Data Collection
- Learning Algorithm Design
- Evaluation

References

Tohme: Detecting Curb Ramps in Google Street View Using Crowdsourcing, Computer Vision, and Machine Learning
Kotaro Hara, Jin Sun, Robert Moore, David Jacobs, Jon Froehlich
27th ACM Symposium on User Interface Software and Technology (**UIST**), Hawaii, United States, 2014. [PDF]

Seeing What Is Not There: Learning Context to Determine Where Objects Are Missing
Jin Sun and David Jacobs
IEEE Conference on Computer Vision and Pattern Recognition (**CVPR**), Hawaii, United States, 2017. [Arxiv]

*slides from Kotaro Hara

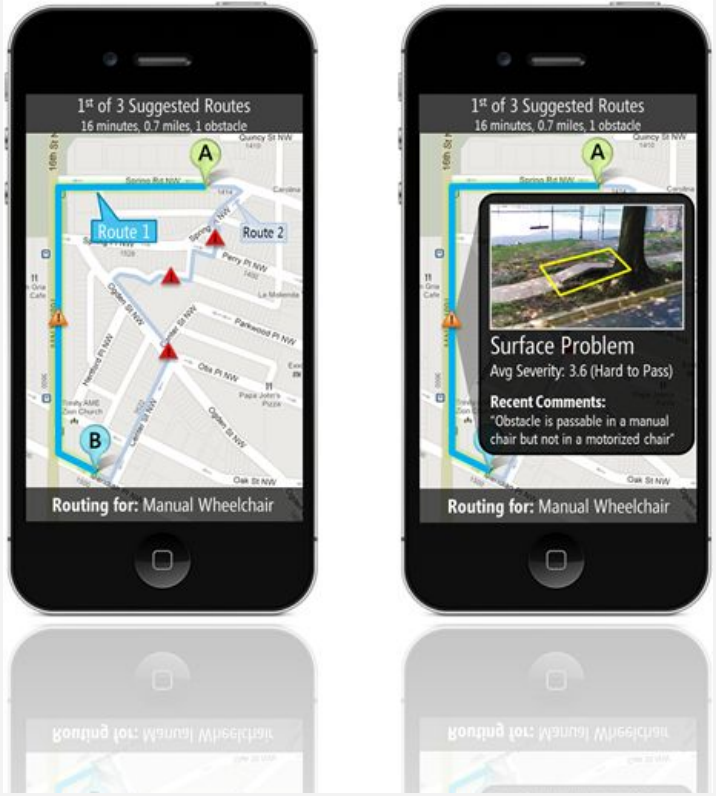
Identify A Real World Problem

Navigation For Cars

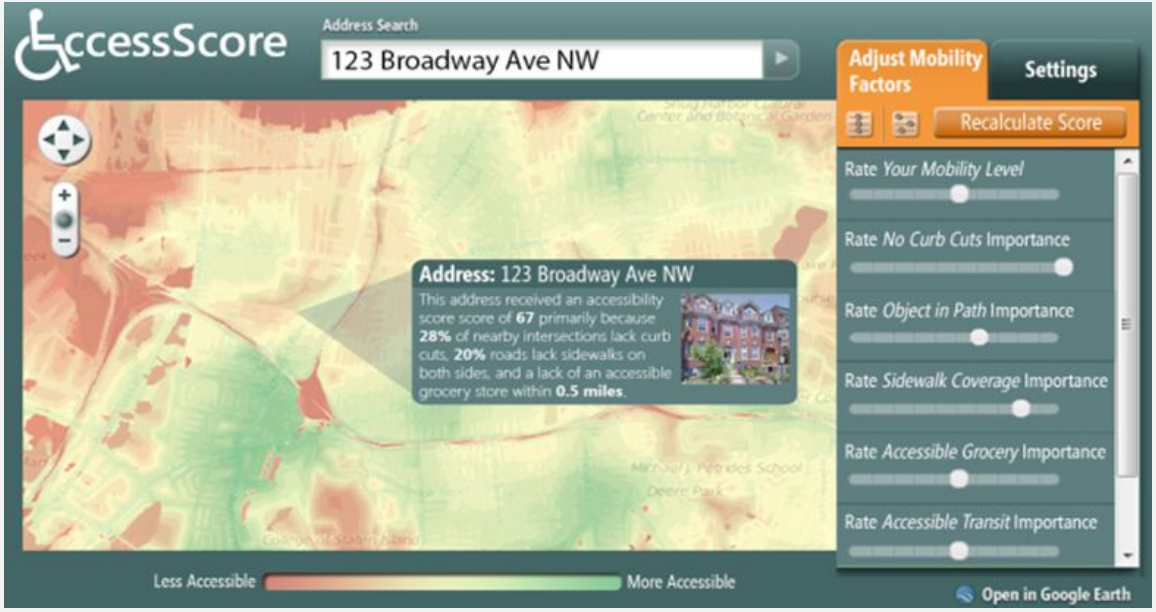
Navigation For Pedestrians

Navigation For Pedestrian With Disabilities

A Desired Solution - Accessibility-aware App



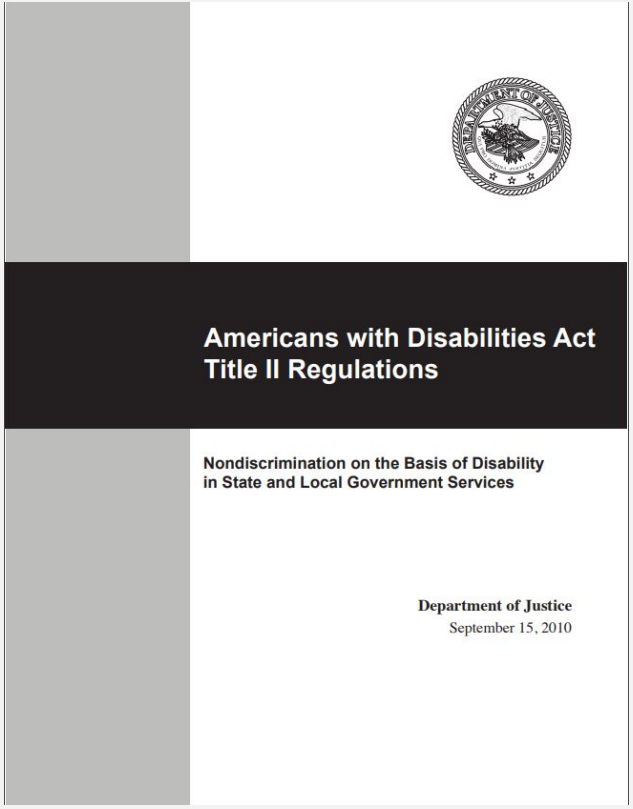
A Desired Solution - City Scale Map

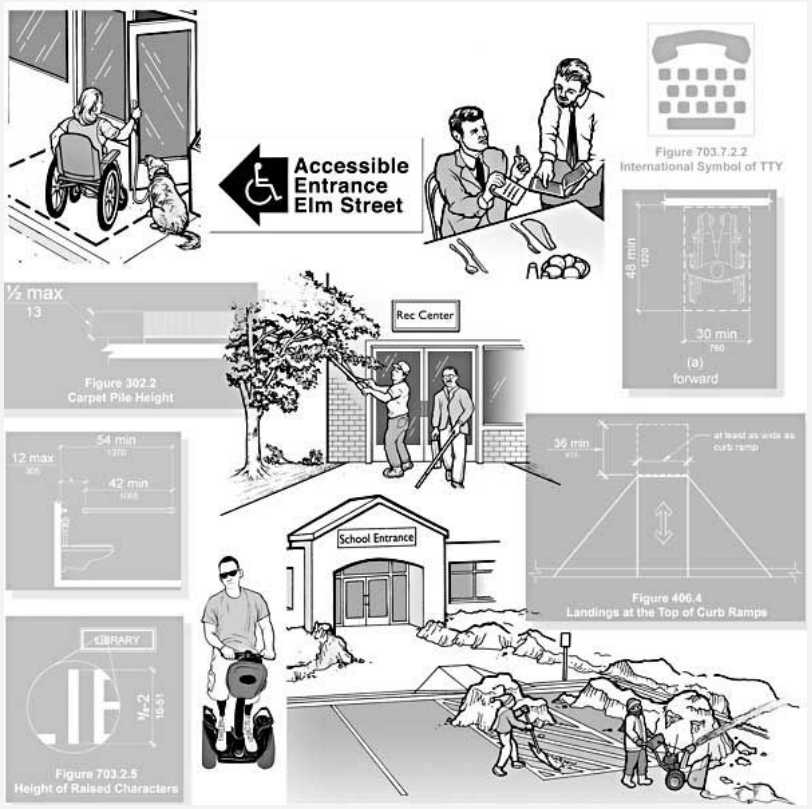


An Important Social Issue

30.6 million people in US (Census 2010) are with physical disabilities.

And Required by Law





Status Quo of Accessibility Assessment

Survey

Physical Audit

Survey

Physical Audit

A Machine Learning Approach?

Scalable

Low-cost

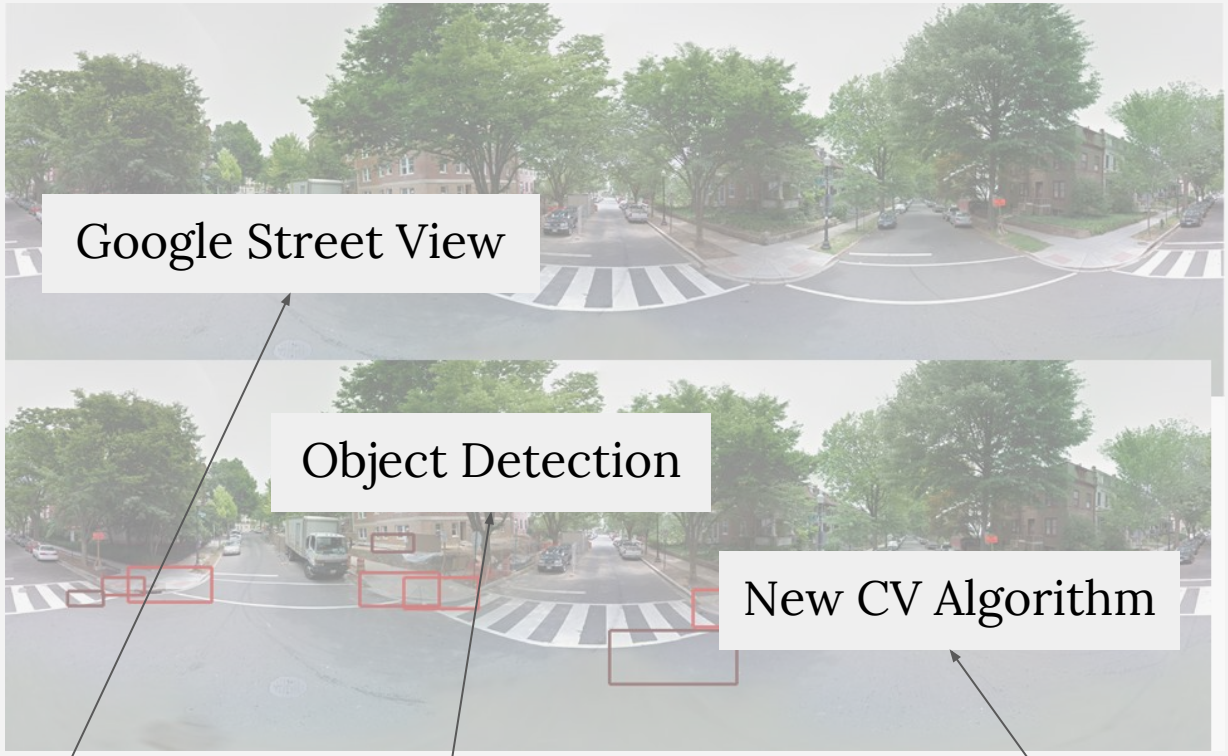
Formulate A Concrete ML/DL Problem

Many Aspects of Accessibility Assessment

A Concrete (Focused) Problem

Collect information on where a curb ramp is and where a curb ramp is missing.

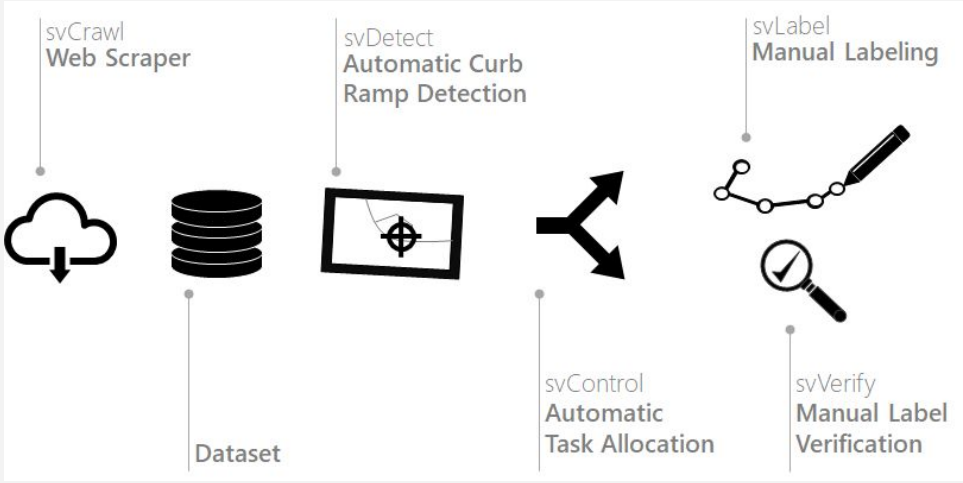
A Concrete (Focused) Problem



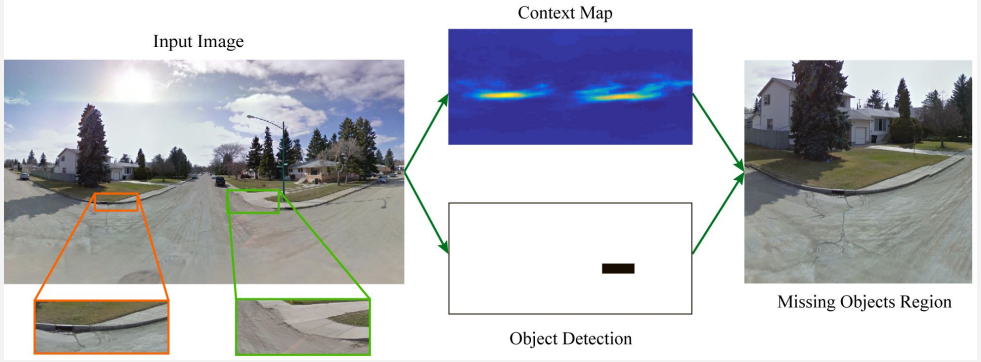
Collect information on where a curb ramp is and where a curb ramp is missing.

Final System

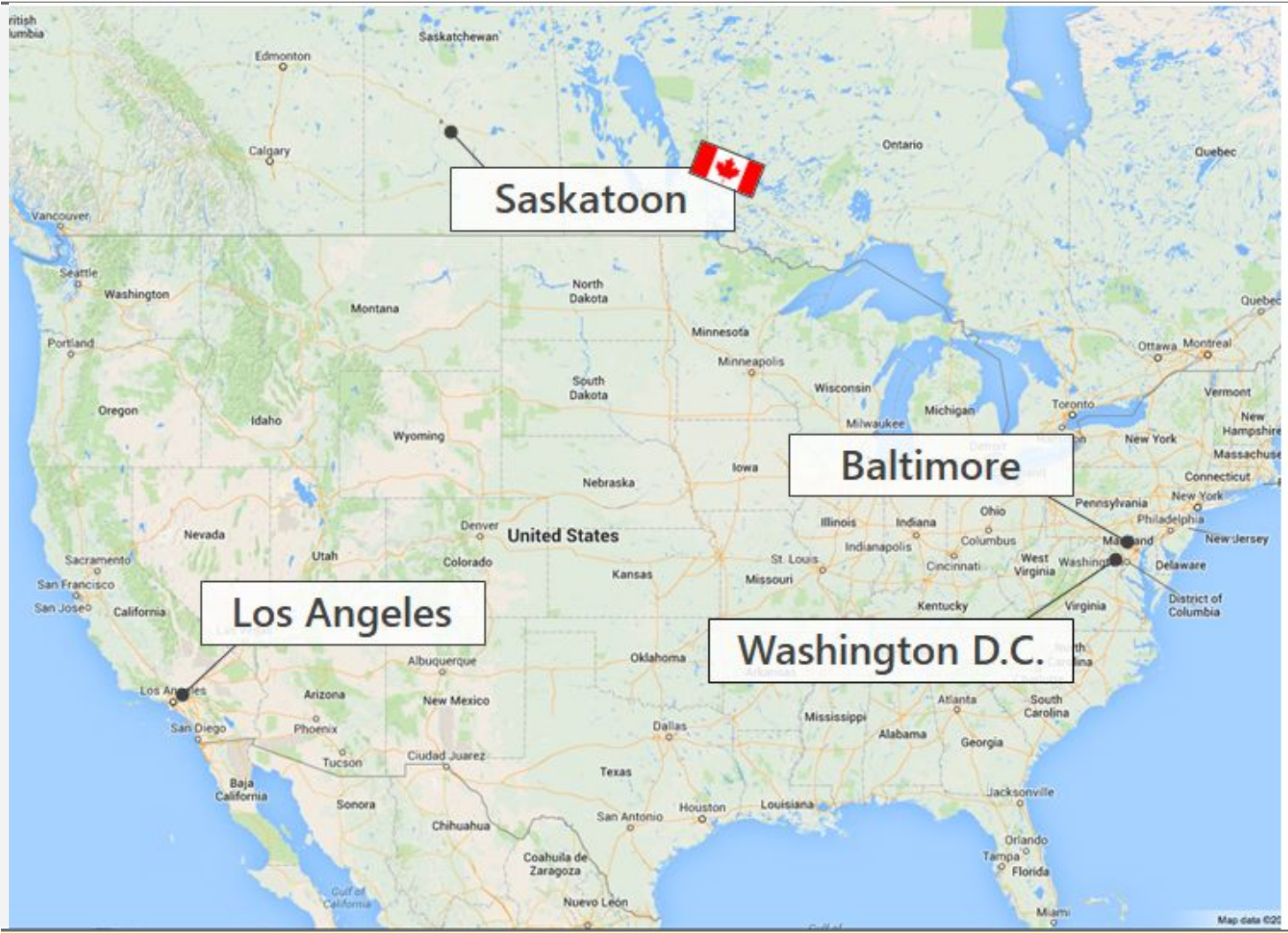
Existing Curb Ramp Detection



Missing Curb Ramp Detection



Data Collection


Saskatoon
Baltimore
Los Angeles
Washington D.C.
Saskatchewan
Edmonton
Calgary
Ontario
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Vancouver
Seattle
Washington
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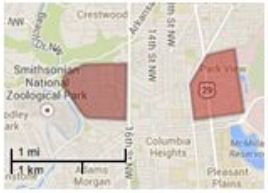
Minnesota
Minneapolis
Portland
Oregon
Idaho
Wyoming
South Dakota
Wisconsin
Michigan
Milwaukee
Toronto
Ottawa
Montreal
Vermont
New Hampshire
New York
Massachusetts
Connecticut
Pennsylvania
Philadelphia
New Jersey
Delaware
District of Columbia
Virginia
Kentucky
West Virginia
Ohio
Columbus
Cincinnati
Indiana
Indianapolis
Illinois
St. Louis
Missouri
Iowa
Nebraska
Kansas
Colorado
Denver
United States
Nevada
Utah
Sacramento
San Francisco
San Jose
California
Los Angeles
San Diego
Phoenix
Tucson
Arizona
New Mexico
Albuquerque
Oklahoma
Texas
Dallas
Houston
San Antonio
Louisiana
Mississippi
Alabama
Georgia
Atlanta
South Carolina
Jacksonville
Orlando
Tampa
Florida
Miami
Ciudad Juarez
Chihuahua
Sonora
Baja California
Coahuila de Zaragoza
Nuevo León
Gulf of California
Washington D.C.
Baltimore
Los Angeles
Saskatoon



Washington D.C. Baltimore Los Angeles Saskatoon

Total Area: 11.3 km²

Intersections: 1,086

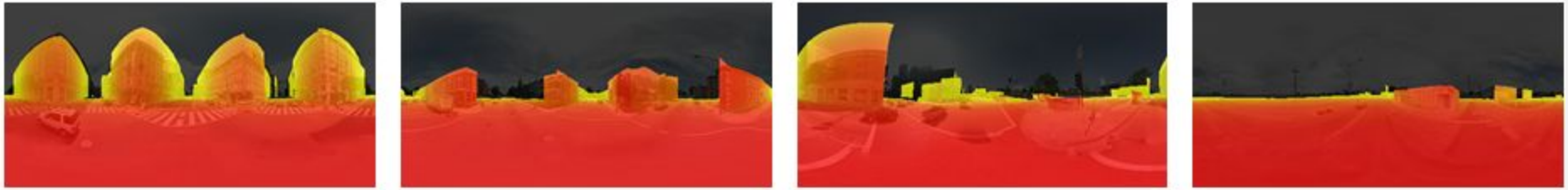
Curb Ramps: 2,877

Missing Curb Ramps: 647

Avg. GSV Data Age: 2.2 yr*

Google Street View (GSV) Panoramas

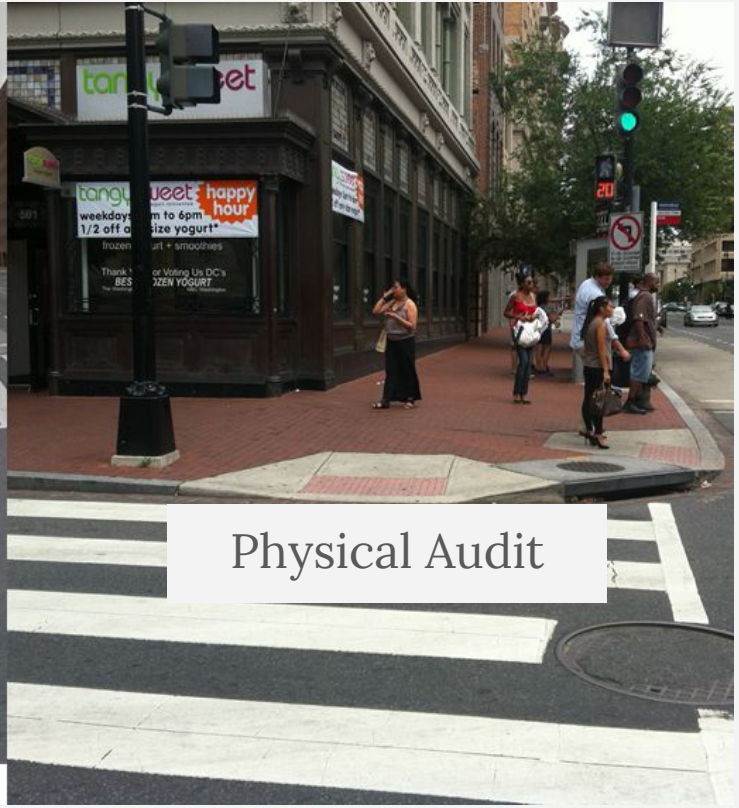
3D Point-cloud Data



Top-down Google Maps

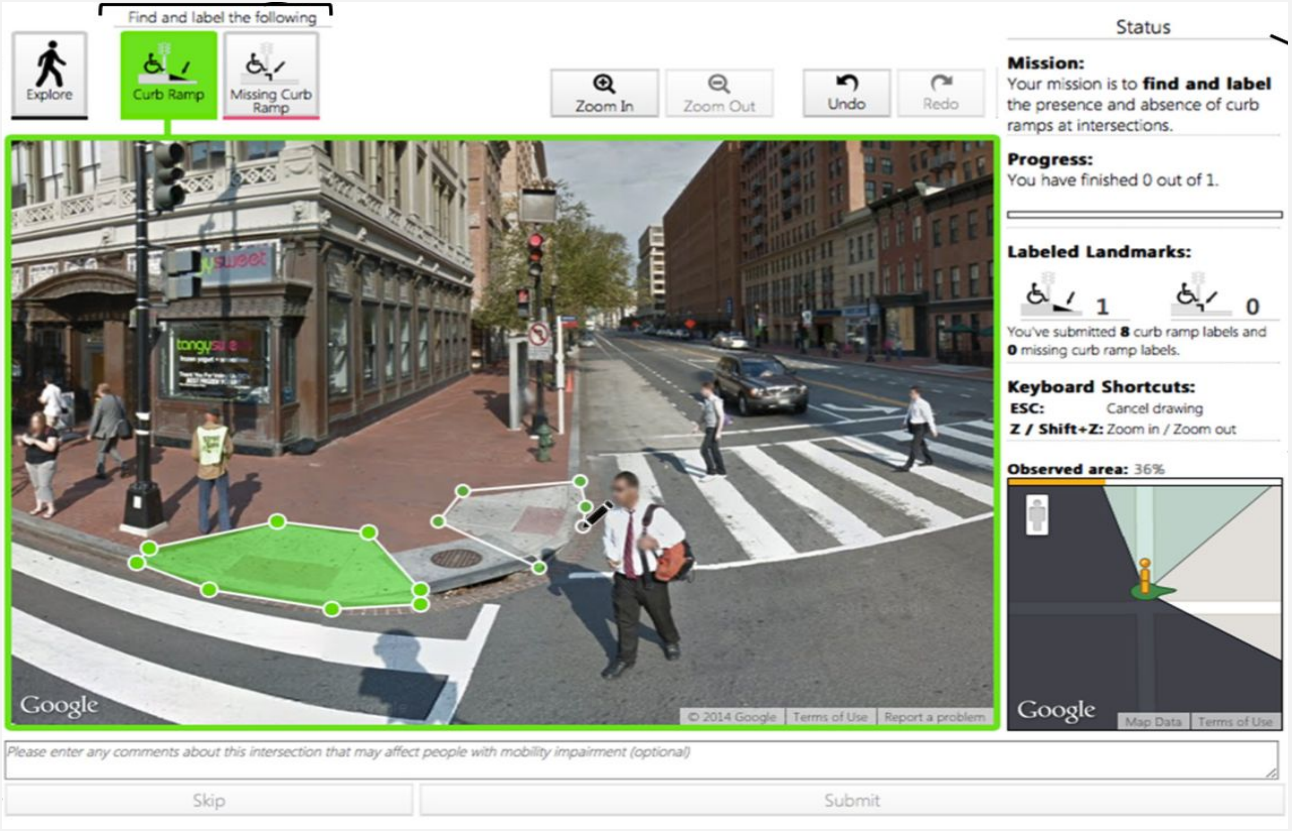
Is GSV a Faithful Source?

GSV



Physical Audit

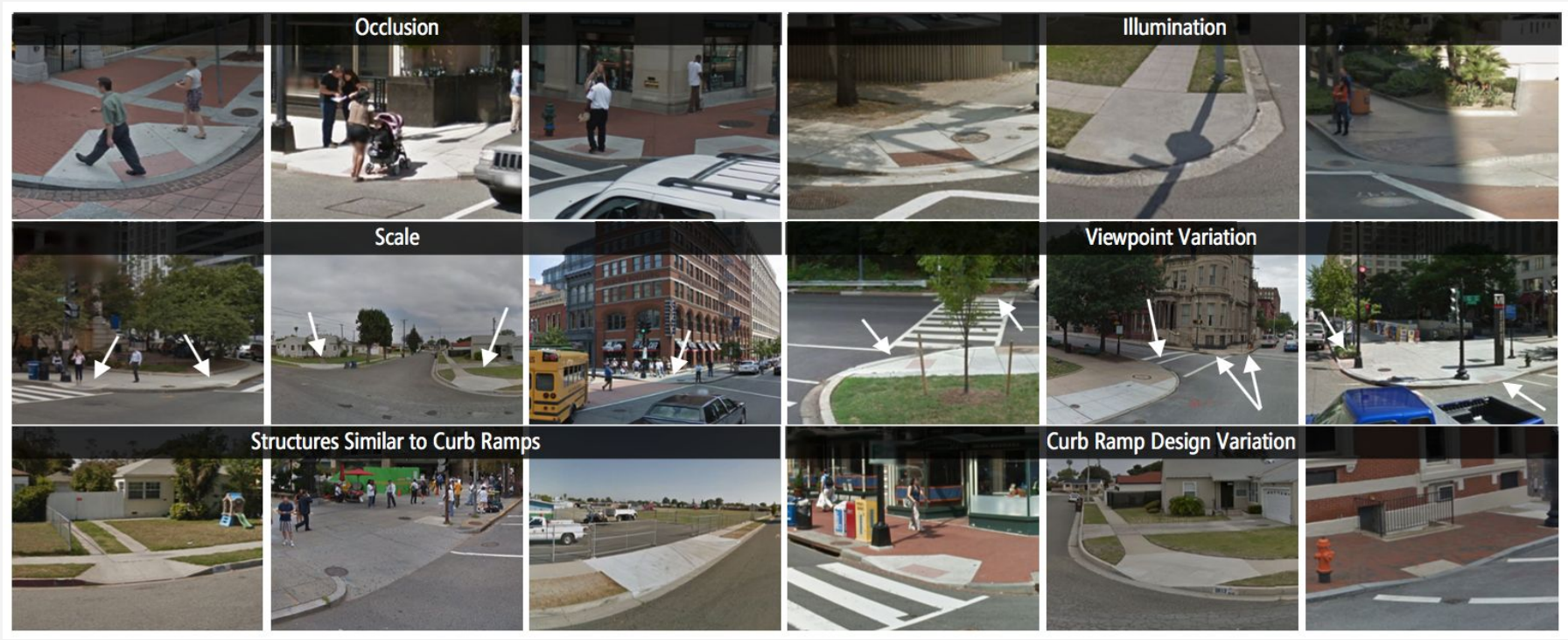
Data Annotation



Ground-truth Labels:

2877 curb ramp labels

Existing Curb Ramps

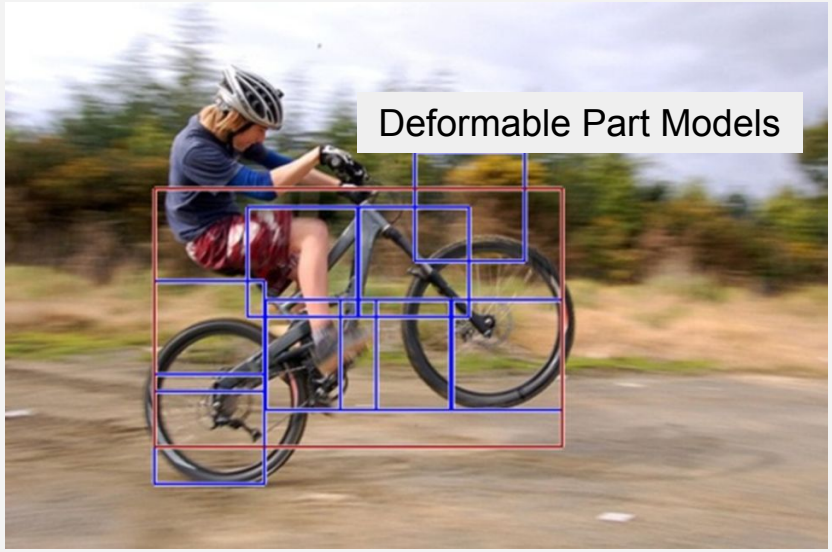


Same labeling scheme is used for missing curb ramp regions: just a different label.

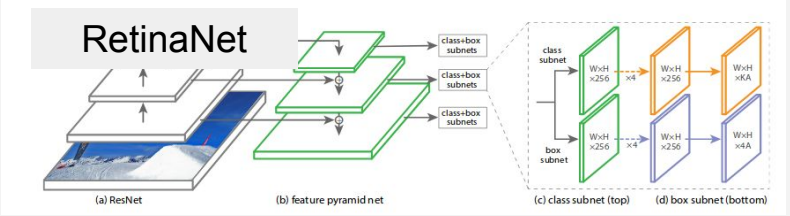
Learning Algorithm Design

Object Detection

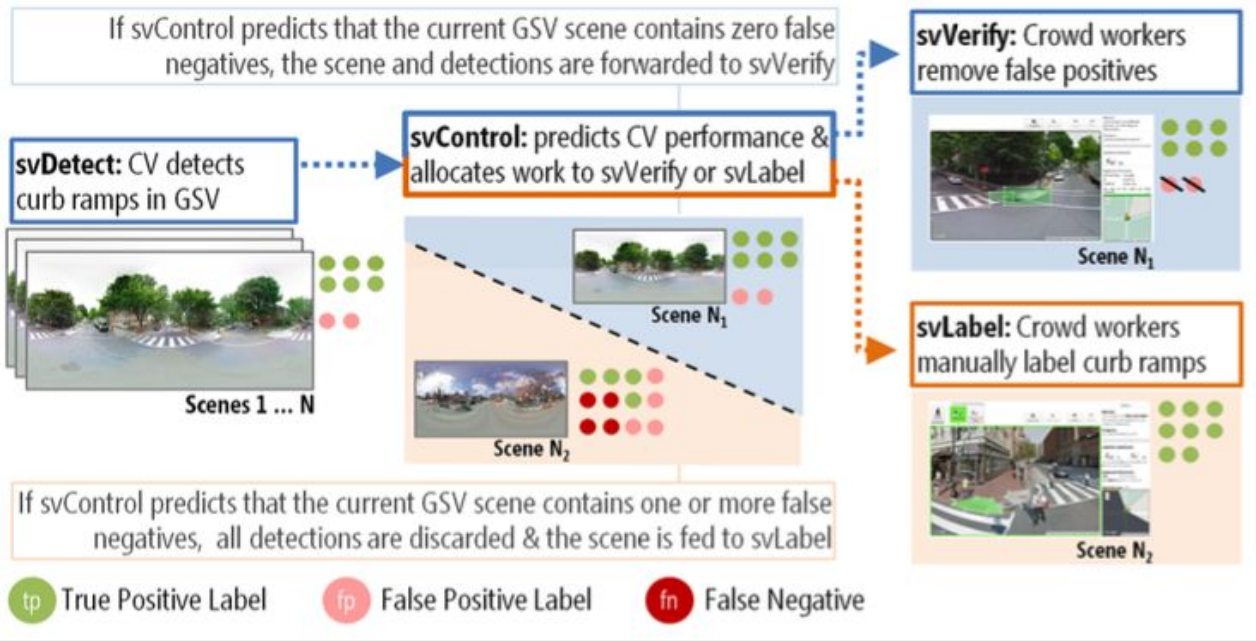
At that time



Now



A Pipeline Combines Crowdsourcing and ML/CV



Finding Missing Object Region

What does it mean when we say ‘an object is missing from a region’?

An **object** is not in its **typical environment (context)**.

Context-Object Relationship

Object Score	Context Score	Image Region Remark
High	High	Typical Objects
Low	High	Missing Objects
High	Low	Out of Context Objects

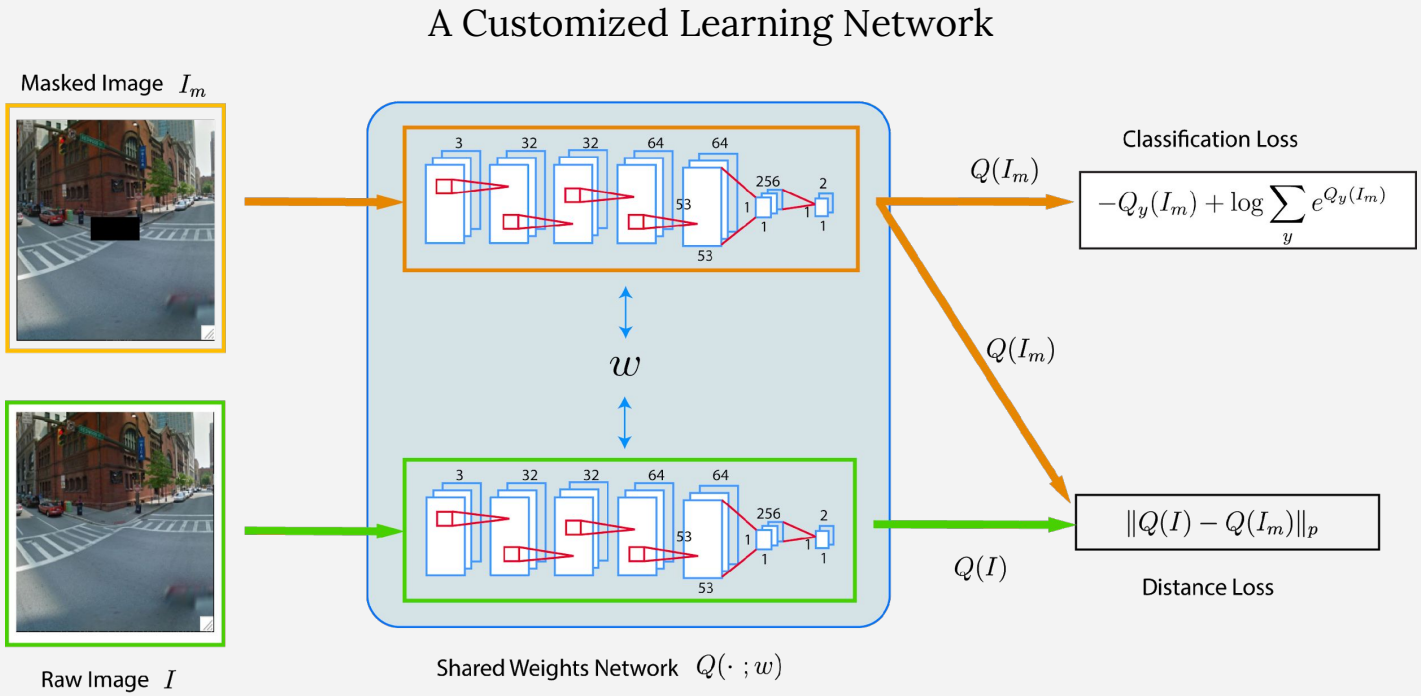
Context-Object Relationship

Object Score	Context Score	Image Region Remark
High	High	Typical Objects
Low	High	Missing Objects
High	Low	Out of Context Objects

Context-Object Relationship

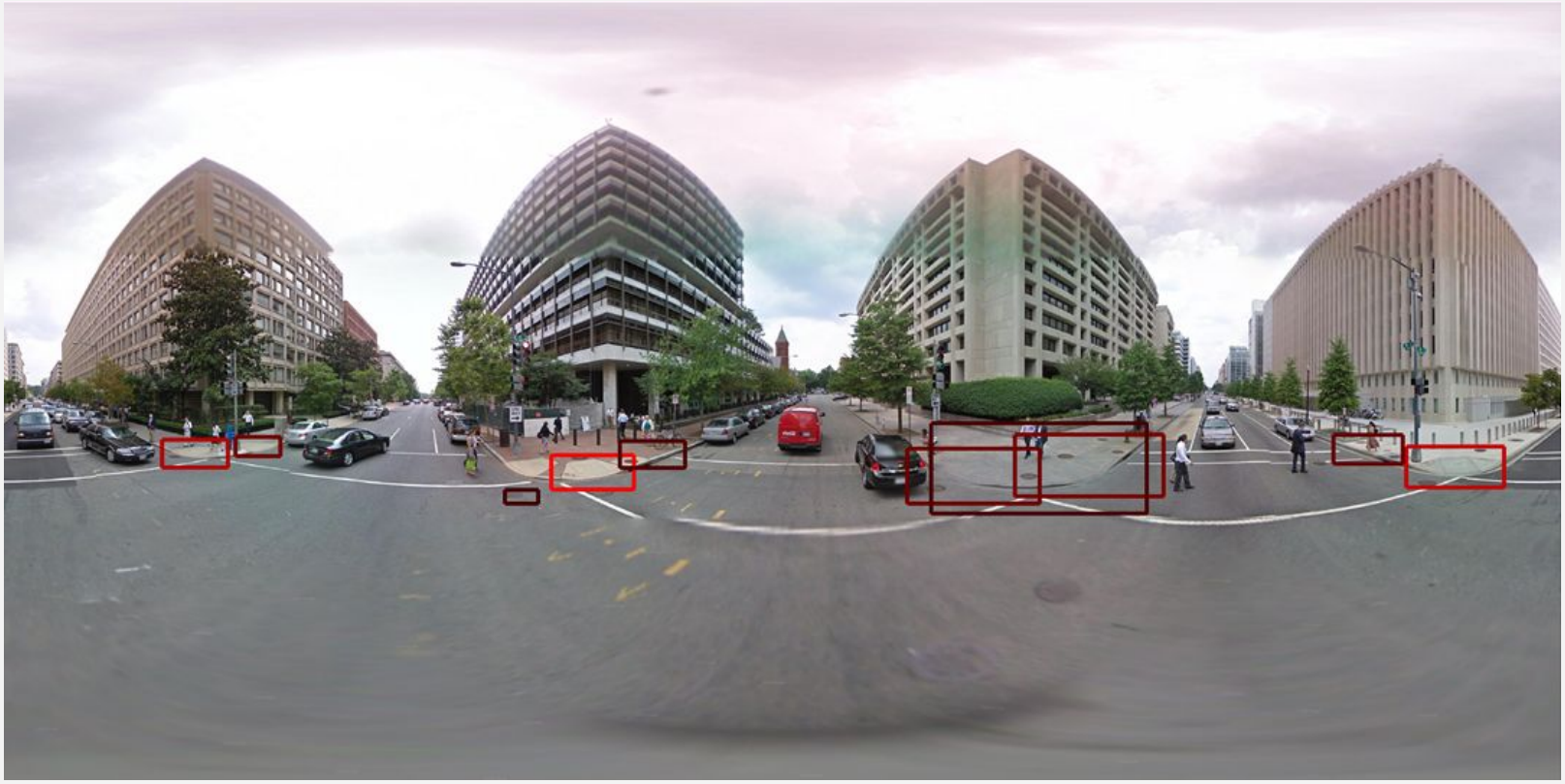
Object Score	Context Score	Image Region Remark
High	High	Typical Objects
Low	High	Missing Objects
High	Low	Out of Context Objects

Find Missing Object Region

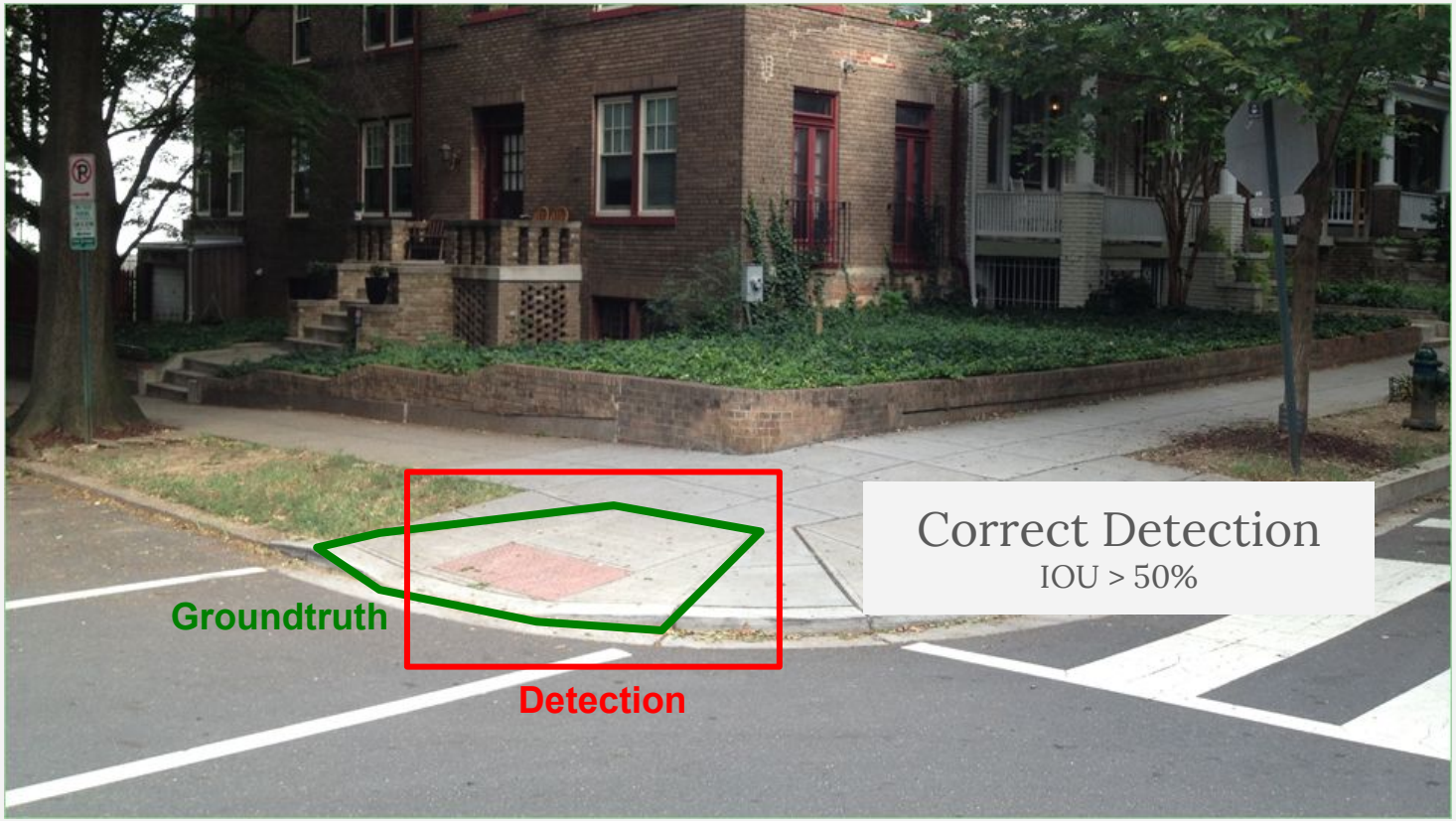


Evaluation

Curb Ramp Detection Results



Curb Ramp Detection Results

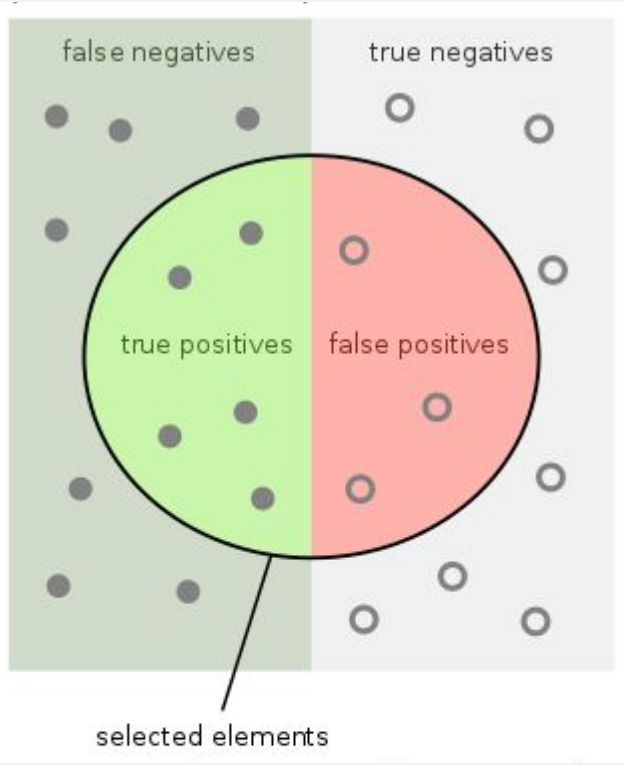


Classification Metric

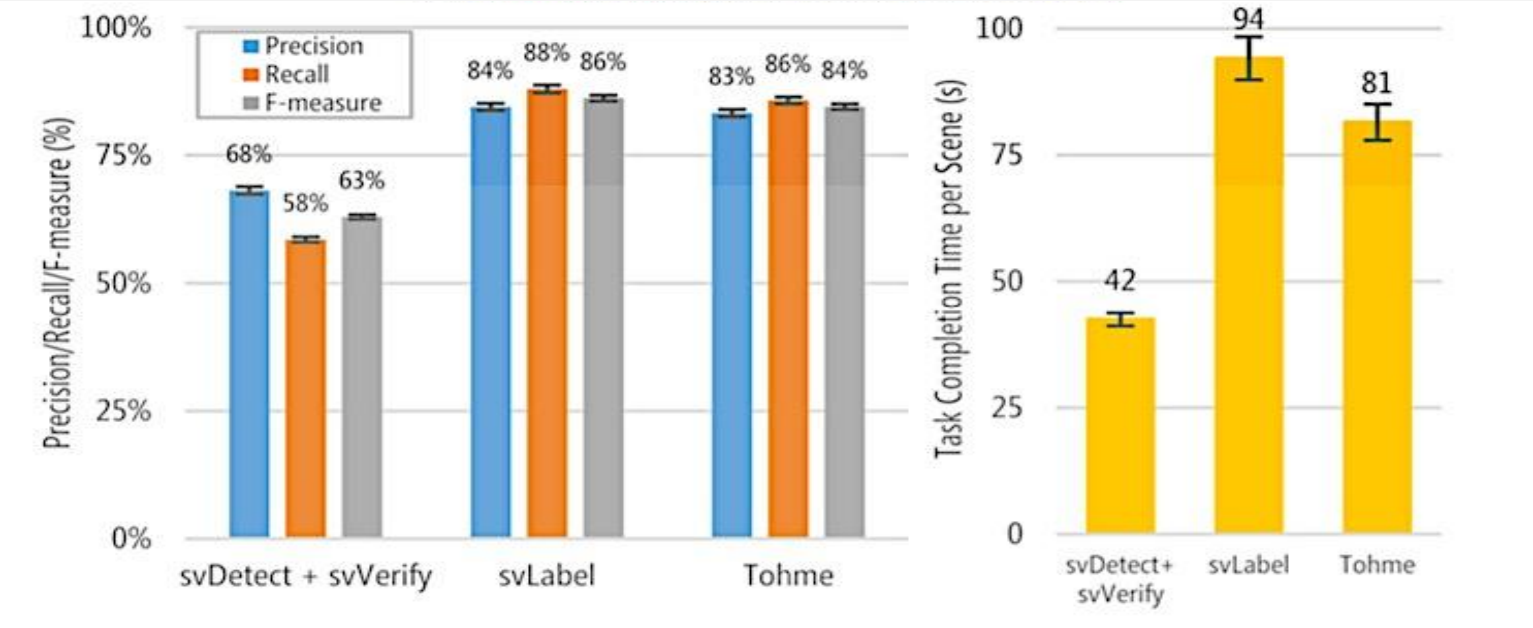
From Lecture 3:

Precision = TP / (TP+FP)

Recall = TP / (TP+FN)



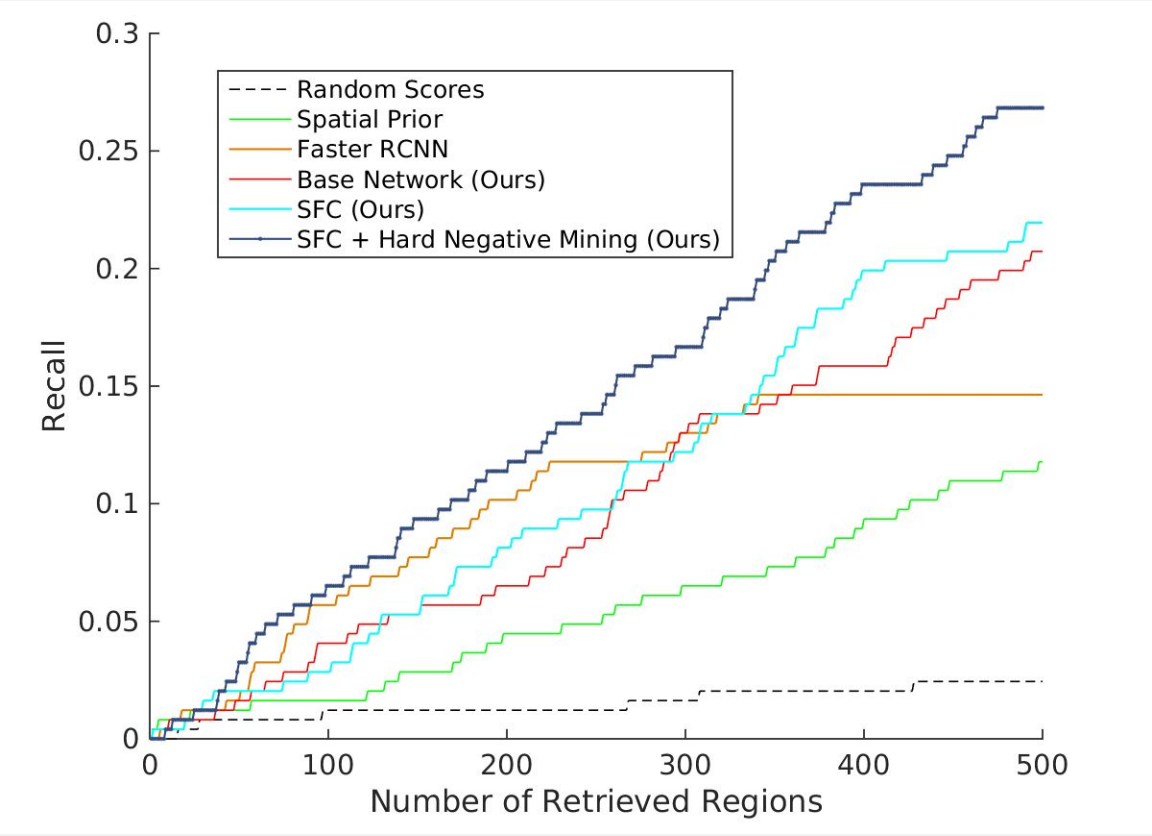
Curb Ramp Detection Performance



Finding Missing Curb Ramp Results

Green: Correct Missing Curb Ramp Regions. **Blue**: False Positives. **Red**: Wrong Predictions

Finding Missing Curb Ramp Performance



What Those Number Imply

2,820 intersections in Manhattan (1.6 million population)

- Assume 10K curb ramps
- Curb ramp detection algorithm can find ~9700 of them.
- Full audit on missing curb ramps takes a few hours
- Useful as a prior for physical audit

Summary

Solving A Real World Problem Using ML/DL

- Identify A Real World Problem
  - Accessibility Assessment
- Formulate A Concrete ML/DL Problem
  - Existing Curb Ramp Detection -- Object Detection
  - Missing Curb Ramp Detection -- A New Learning Problem
- Data Collection
  - Google Street View (GSV)
  - Annotation
- Learning Algorithm Design
  - Detection Pipeline
- Evaluation
  - Curb Ramp Detection Accuracy
  - Missing Curb Ramp Region Retrieval Performance