MAKING WITH A SOCIAL PURPOSE

Jon Froehlich | Assistant Professor | Computer Science

HCIL Human Computer Interaction Laboratory

MAKEABILITY LAB

COMPUTER SCIENCE
UNIVERSITY OF MARYLAND

UNIVERSITY OF MARYLAND


MAKEABILITY LAB
http://makeabilitylab.io


HCIL
MAKEABILITY LAB


Aqua-Bound
WERNER
HCIL
230
MAKEABILITY LAB

Our Mission

DESIGN, BUILD, & STUDY INTERACTIVE TOOLS & TECHNIQUES TO ADDRESS PRESSING SOCIETAL CHALLENGES

MAKEABILITY LAB

FOUR FOCUS AREAS

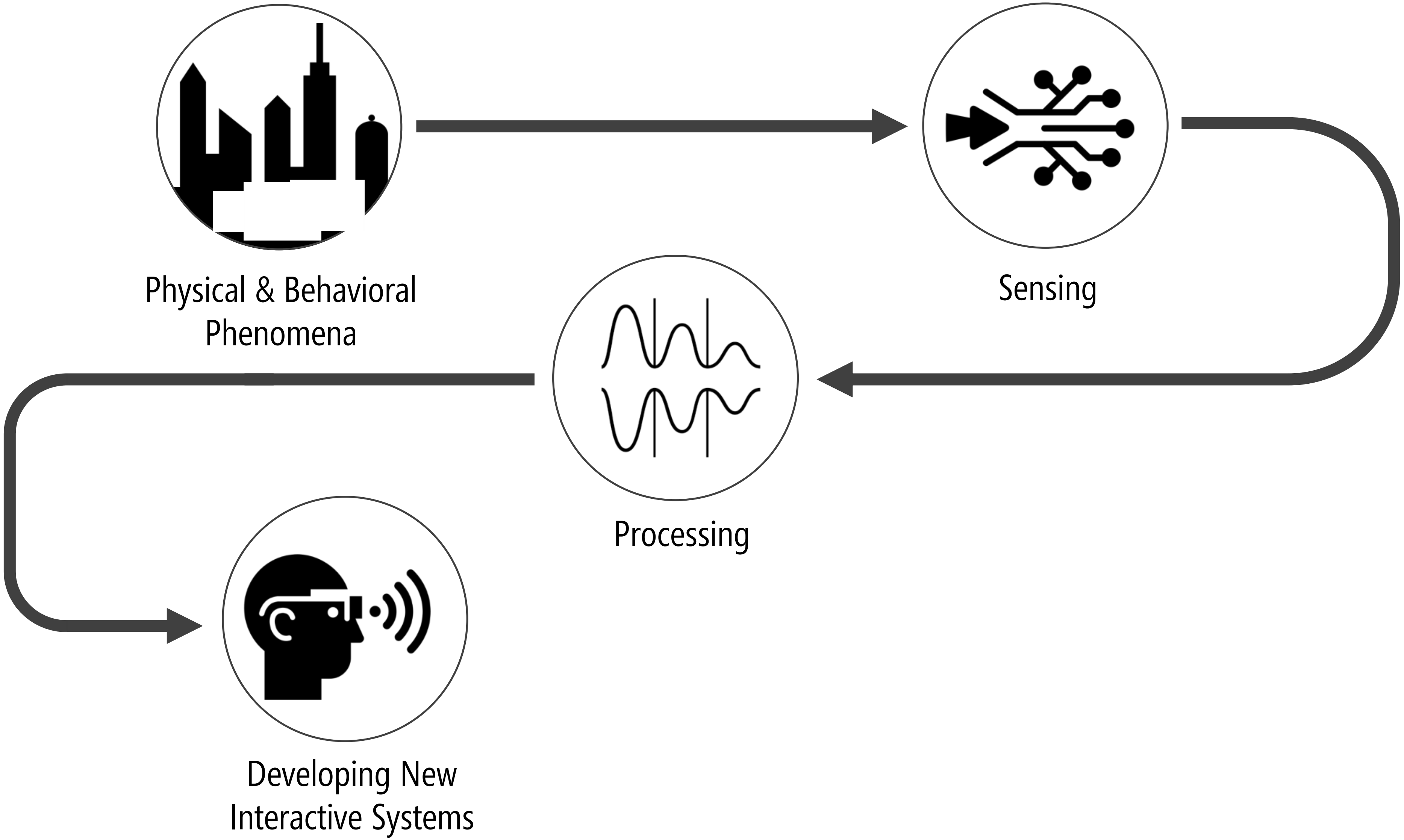
ENVIRONMENTAL SUSTAINABILITY

HEALTH & WELLNESS

ACCESSIBILITY

STEM EDUCATION

APPROACH


Physical & Behavioral Phenomena
Sensing
Processing
Developing New Interactive Systems

ITERATIVE RESEARCH PROCESS

Formative Studies

Prototyping

Lab-based Studies

Refinement

Field Deployments

MAKEABILITY LAB

FOUR FOCUS AREAS

ENVIRONMENTAL SUSTAINABILITY

HEALTH & WELLNESS

ACCESSIBILITY

STEM EDUCATION

MAKEABILITY LAB

FOUR FOCUS AREAS

ENVIRONMENTAL SUSTAINABILITY

HEALTH & WELLNESS

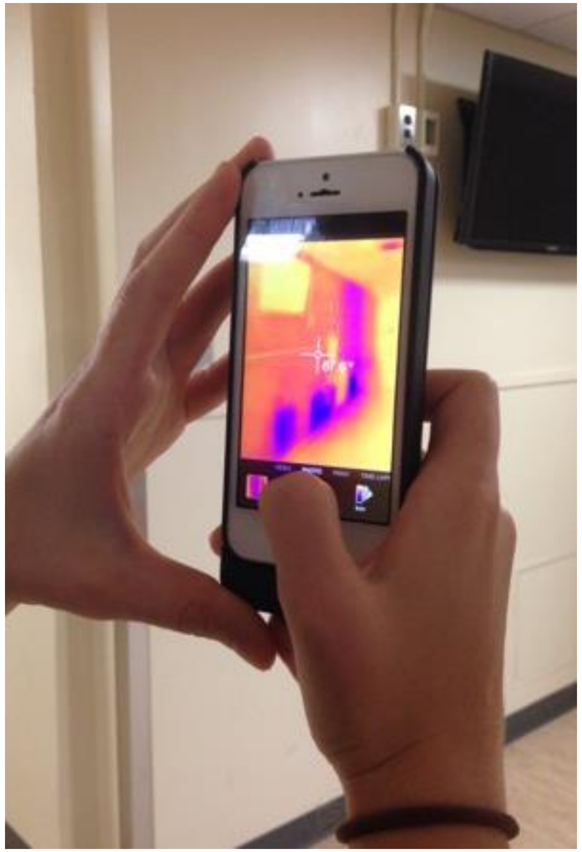
ACCESSIBILITY

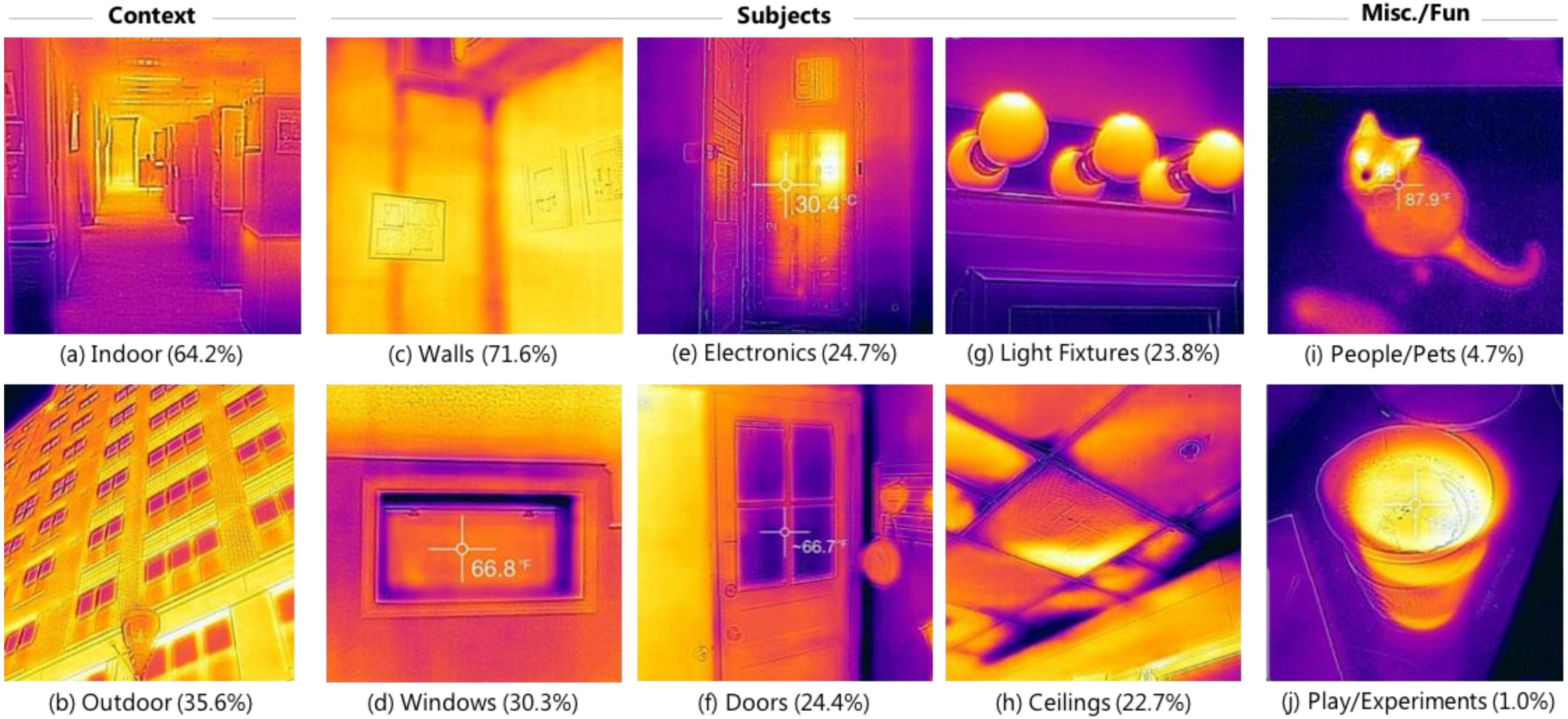
STEM EDUCATION

ENVIRONMENTAL SUSTAINABILITY

PERVASIVE THERMOGRAPHY

With UMD CS PhD Student Matt Mauriello





[UbiComp'13, CHI'15 Honorable Mention, HBI'16, CHI'17]

MAKEABILITY LAB

FOUR FOCUS AREAS

ENVIRONMENTAL SUSTAINABILITY

HEALTH & WELLNESS

ACCESSIBILITY

STEM EDUCATION

HEALTH & WELLNESS

DESIGNING HEALTH SUPPORT SYSTEMS

[CHI'13 Best Paper, CHI'14]

MAKEABILITY LAB

FOUR FOCUS AREAS

ENVIRONMENTAL SUSTAINABILITY

HEALTH & WELLNESS

ACCESSIBILITY

STEM EDUCATION

HEALTH + STEM

BODYVIS

[IDC’13, CHI’15 Honorable Mention, ICLS’16, IDC’16, CHI’17]

MAKEABILITY LAB

FOUR FOCUS AREAS

ENVIRONMENTAL SUSTAINABILITY

HEALTH & WELLNESS

ACCESSIBILITY

STEM EDUCATION

MAKEABILITY LAB

FOUR FOCUS AREAS

ENVIRONMENTAL SUSTAINABILITY

HEALTH & WELLNESS

ACCESSIBILITY

STEM EDUCATION

ENVIRONMENTAL SUSTAINABILITY

HEALTH & WELLNESS

ACCESSIBILITY

STEM EDUCATION

How to...

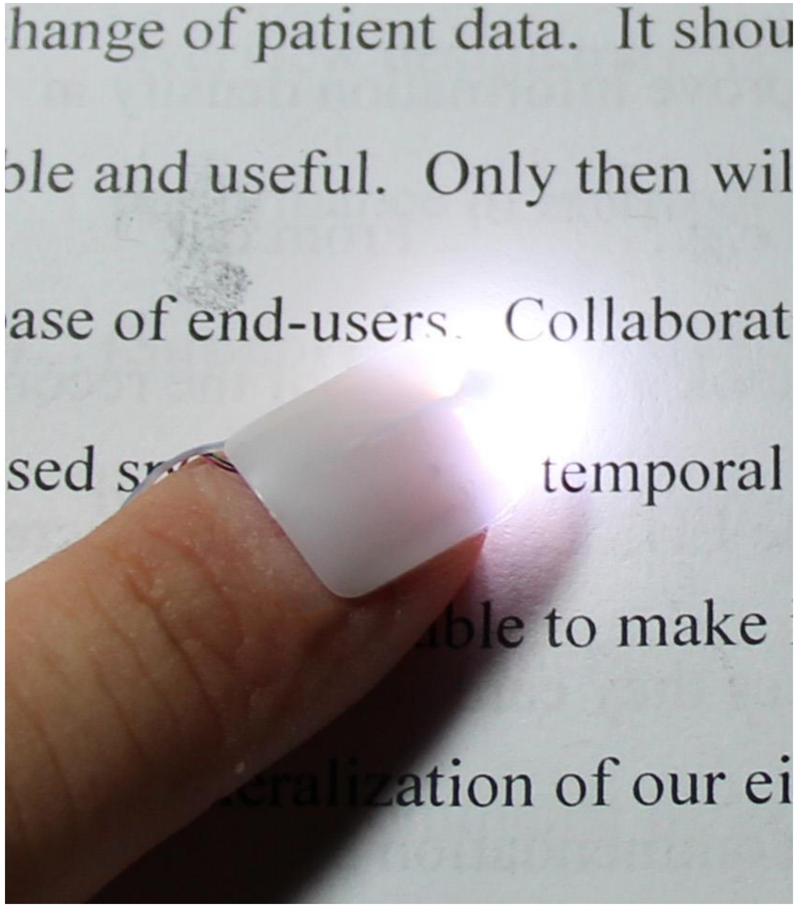
make the *physical world* more accessible for people with disabilities

THREAD 1: ACCESSIBILITY

IMPROVING ACCESS TO THE PHYSICAL WORLD

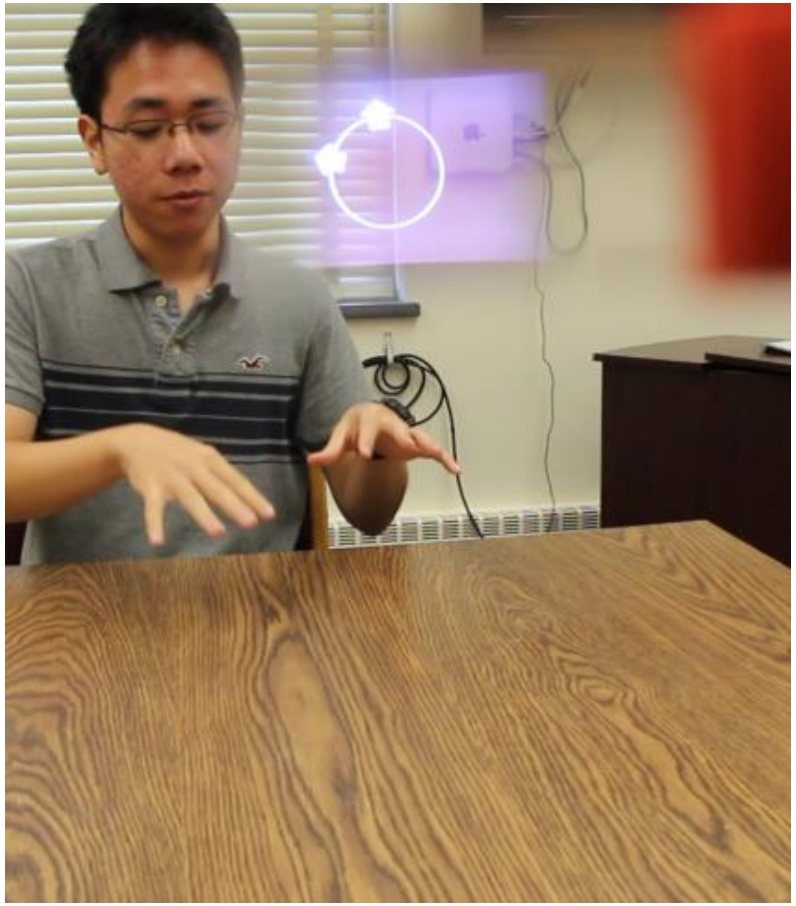
PROJECT SIDEWALK

[ASSETS'12, CHI'13, HCOMP'13, ASSETS'13 Best Paper, UIST'14, TACCESS'15, SIGACCESS'15, CHI'16]



HANDSIGHT

[ACVR'14, ASSETS'15, GI'16, TACCESS'16]



GLASSEAR

[CHI'15]

THREAD 1: ACCESSIBILITY

IMPROVING ACCESS TO THE PHYSICAL WORLD

PROJECT SIDEWALK

[ASSETS'12, CHI'13, HCOMP'13, ASSETS'13 Best Paper, UIST'14, TACCESS'15, SIGACCESS'15, CHI'16]

How can we…

develop scalable solutions that map the accessibility of urban infrastructure?


30.6
million U.S. adults
have a mobility impairment
Source: US Census, 210


15.2
million use an assistive aid
Source: US Census, 210


CHANEL
CHANEL
CHANEL
CHANEL
ONE WAY
NO PARKING
DIESEL


CHANEL
ONE WAY
DIESEL
NO CURB RAMPS


PHYSICAL OBSTACLES


FedEx
INCOMPLETE SIDEWALKS


SURFACE PROBLEMS


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]


Central Av
Tokyo
Salon
GINZA
GINZA

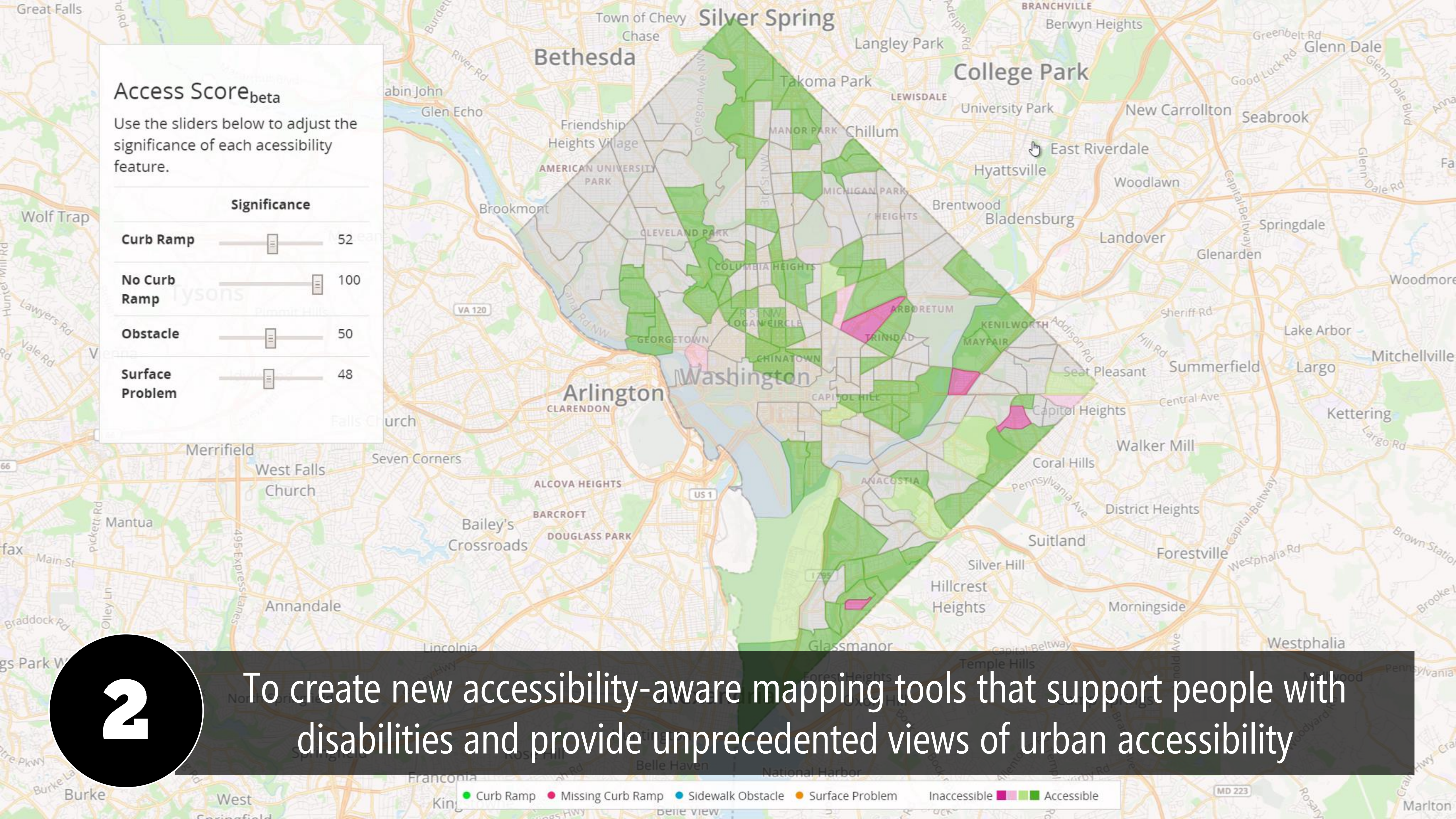
The National Council on Disability noted that there is **no comprehensive information** on "the degree to which sidewalks are accessible" in cities.

National Council on Disability, 2007
The impact of the Americans with Disabilities Act: Assessing the progress toward achieving the goals of the ADA

We are pursuing a **two-fold solution**

1

To develop scalable methods that mine massive repositories of online map imagery to identify accessibility problems semi-automatically



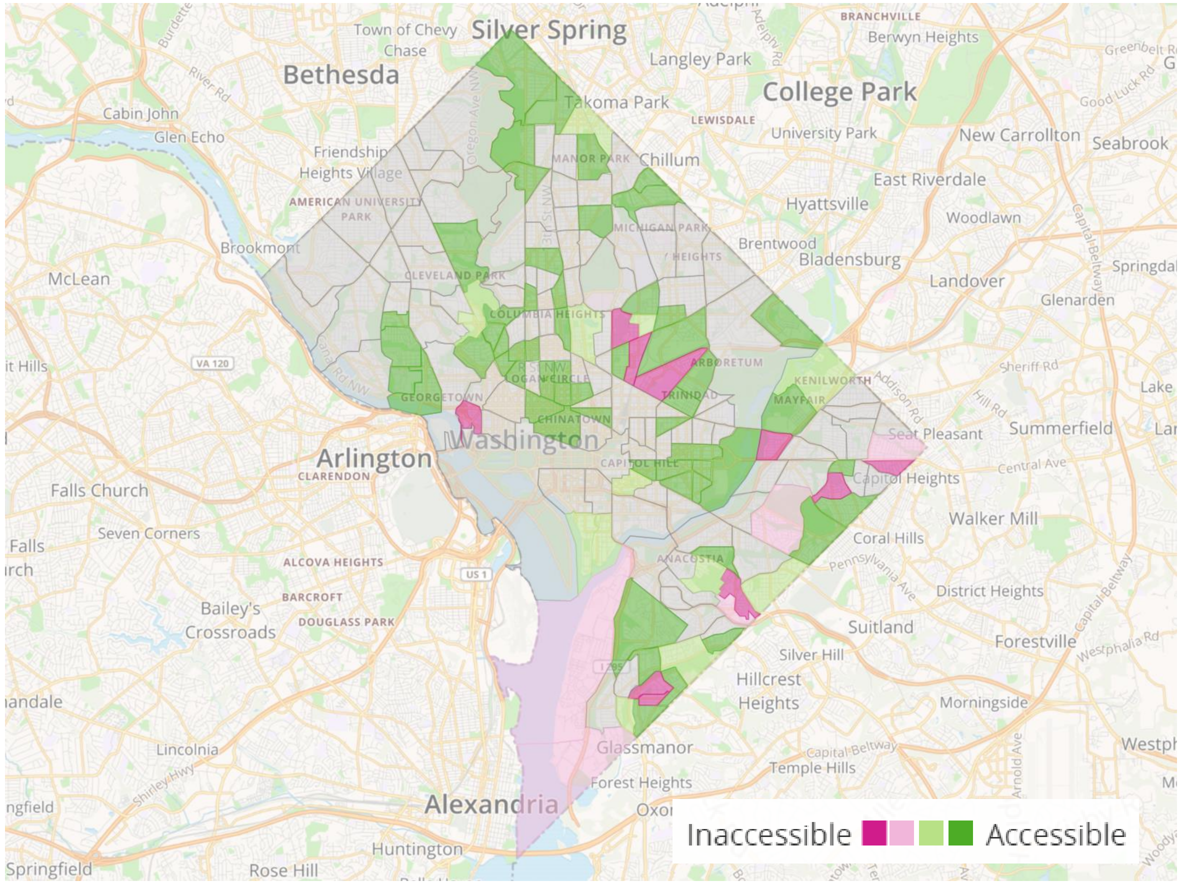
2

To create new accessibility-aware mapping tools that support people with disabilities and provide unprecedented views of urban accessibility

TWO FOCUS AREAS

SCALABLE DATA COLLECTION METHODS

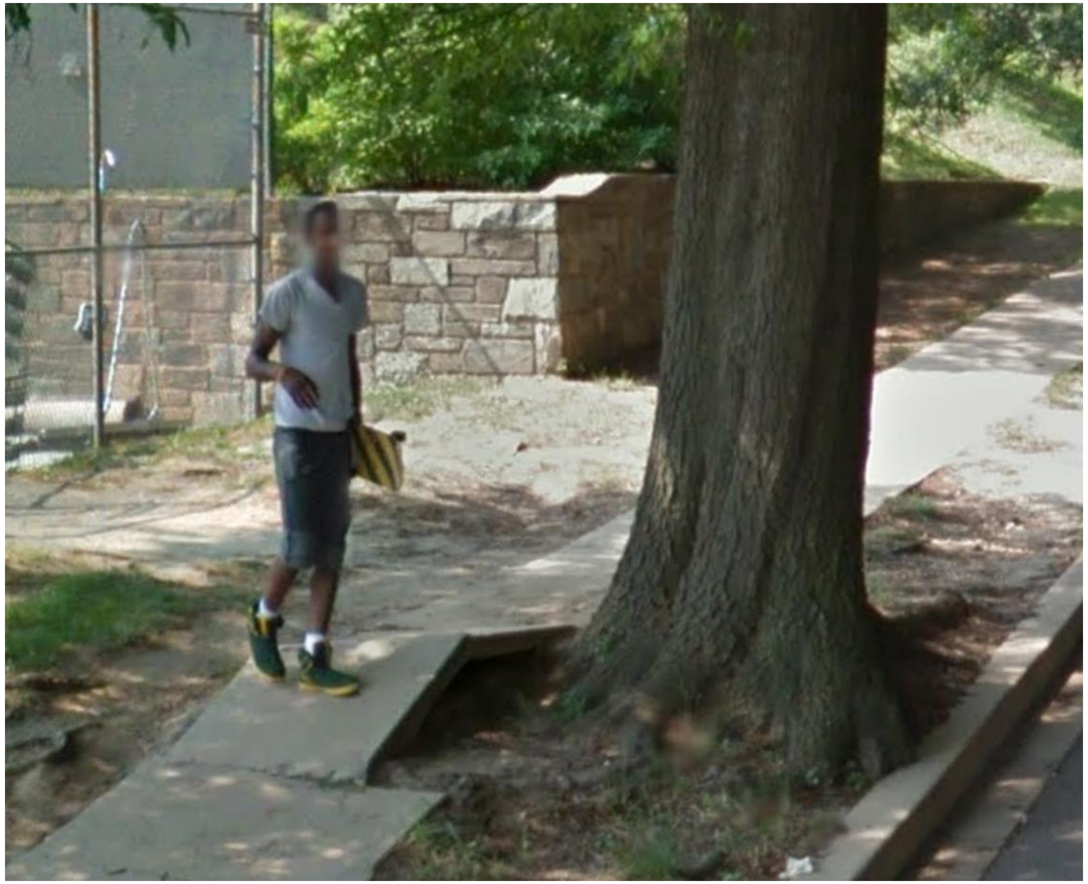
[ASSETS'12, CHI'13, HCOMP'13, ASSETS'13, UIST'14, TACCESS'15]



NEW ACCESSIBILITY GIS TOOLS

[SIGACCESS '15, CHI'16]

KEY RESEARCH QUESTIONS



SCALABLE DATA COLLECTION METHODS

[ASSETS'12, CHI'13, HCOMP'13, ASSETS'13, UIST'14, TACCESS'15]

Is online map imagery a good source for accessibility data?

Can we create interactive tools that enable crowd workers to find accessibility problems?

How can we leverage computational techniques to scale our approach?

MAPPING THE ACCESSIBILITY OF THE WORLD

THE TEAM

PROFESSORS

Jon Froehlich

David Jacobs

GRAD STUDENTS

Kotaro Hara

Manaswi Saha

Jin Sun

Ladan Najafizadeh

Soheil Behnezhad

UNDERGRADUATE STUDENTS

Vicki Le

Robert Moore

Christine Chan

Maria Furman

Daniil Zadorozhnyy

Zach Lawrence

Alex Zhang

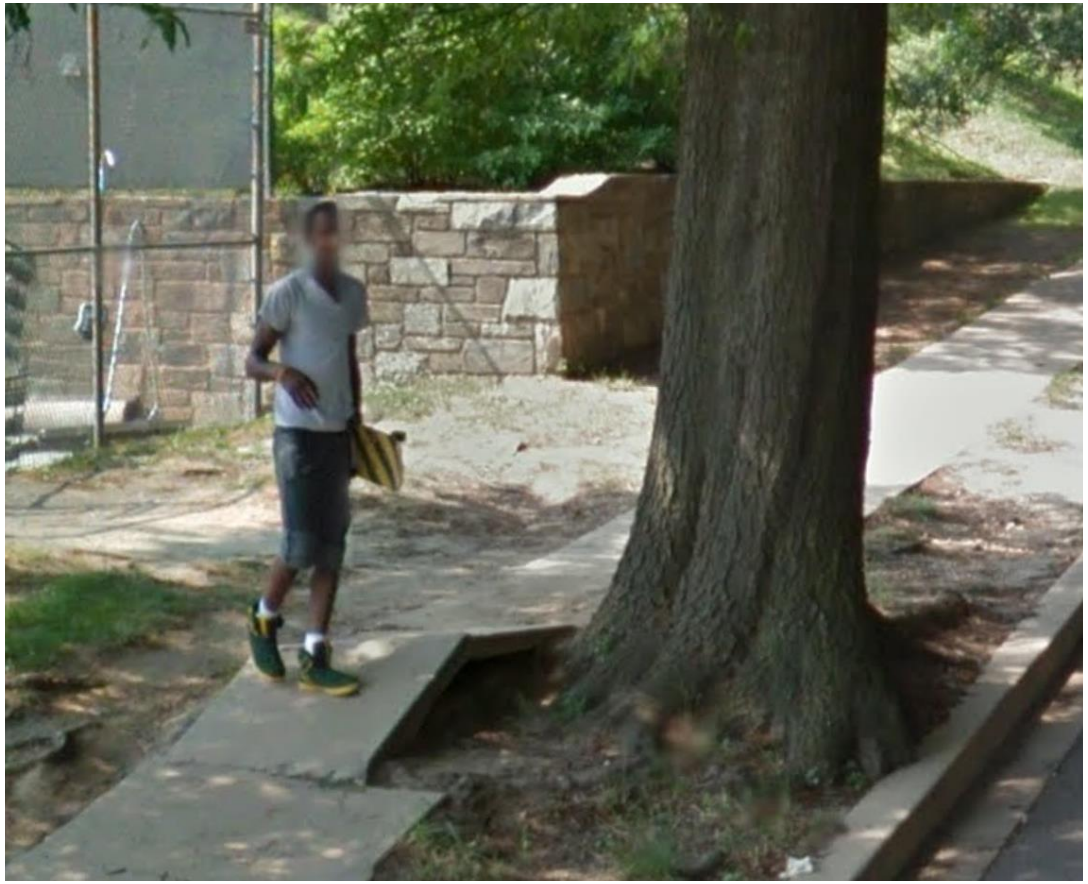
HIGH SCHOOL STUDENTS

Jonah Chazan

Anthony Li

Niles Rogoff

KEY RESEARCH QUESTIONS



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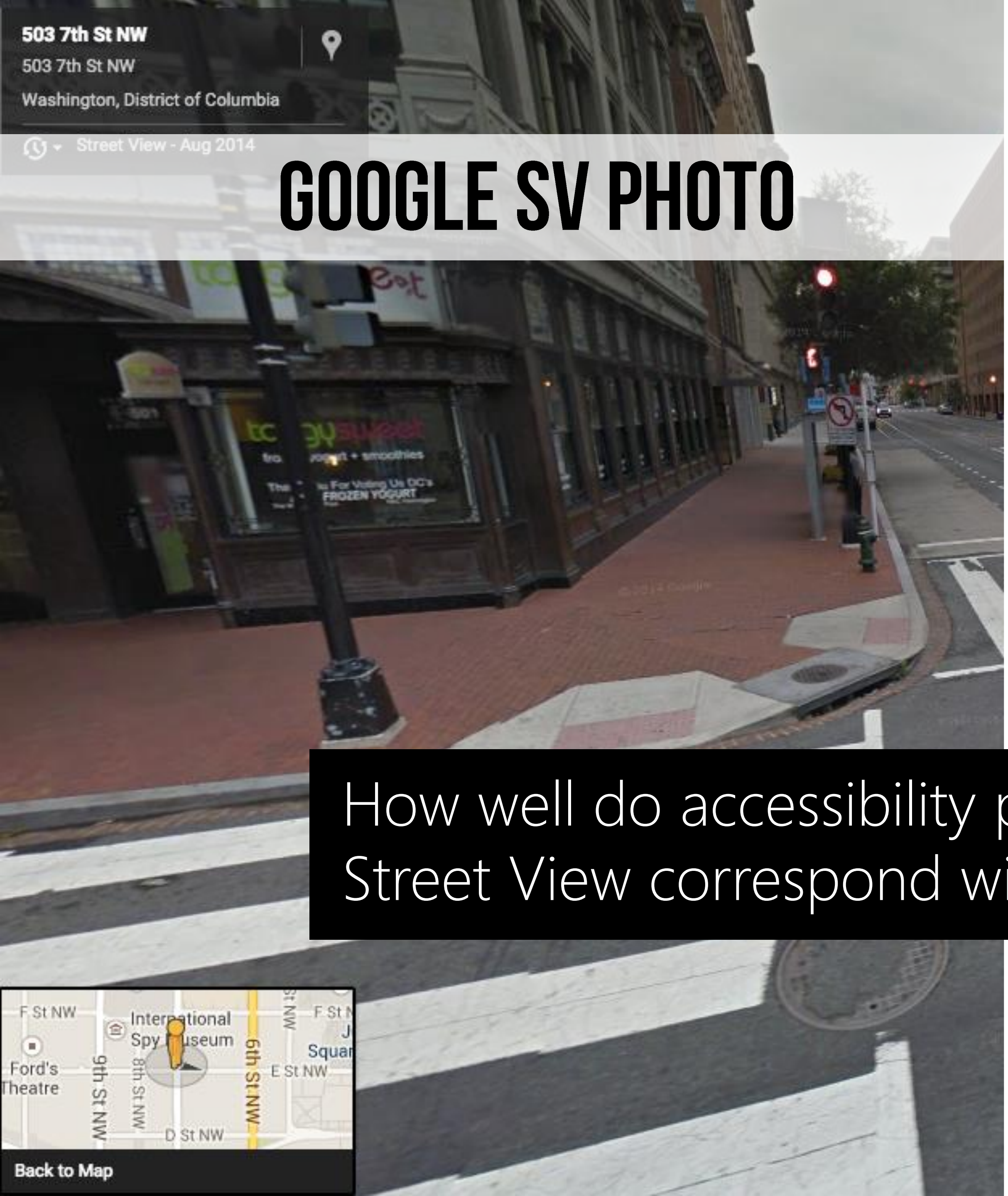
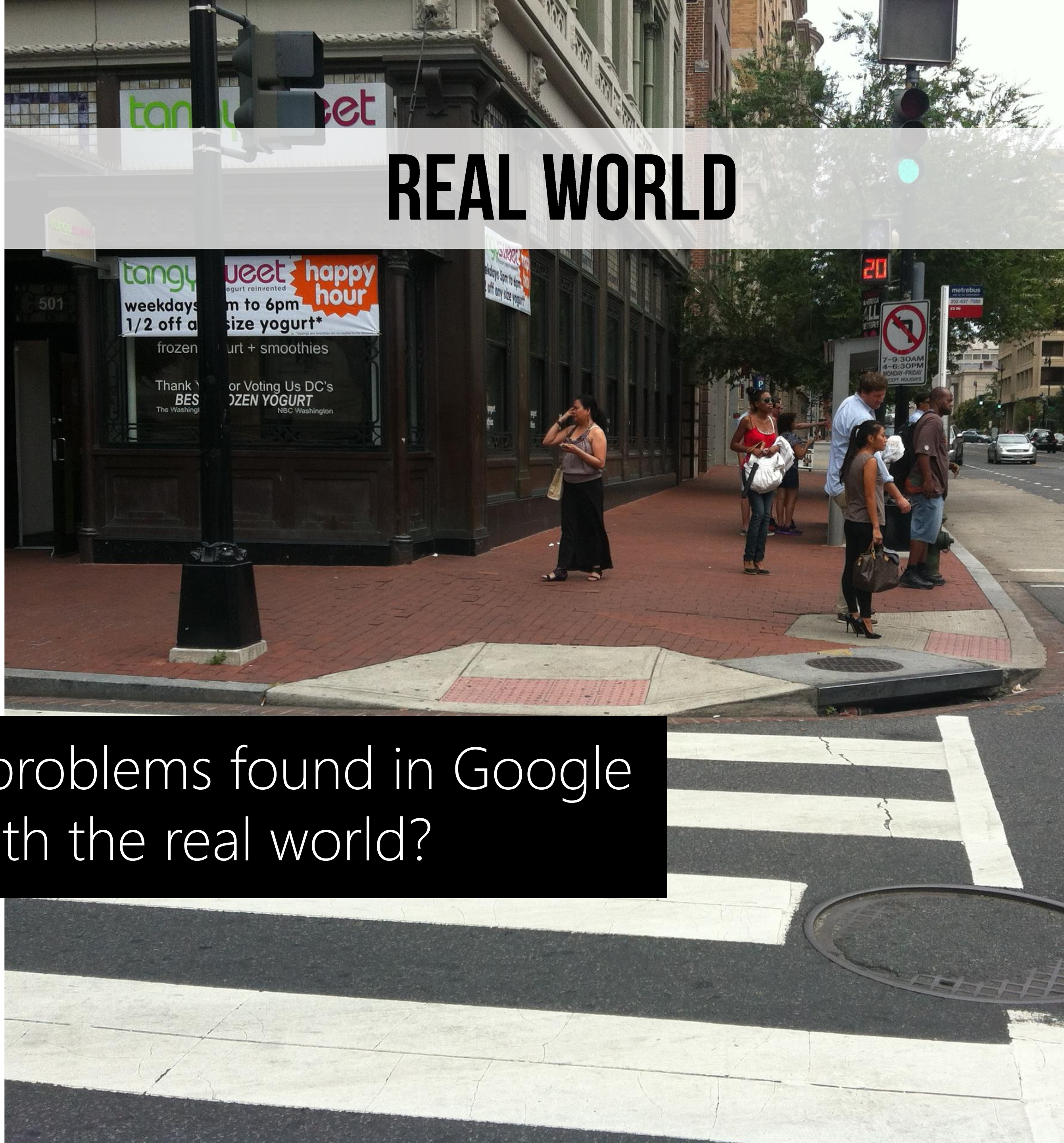
GOOGLE SV PHOTO



REAL WORLD



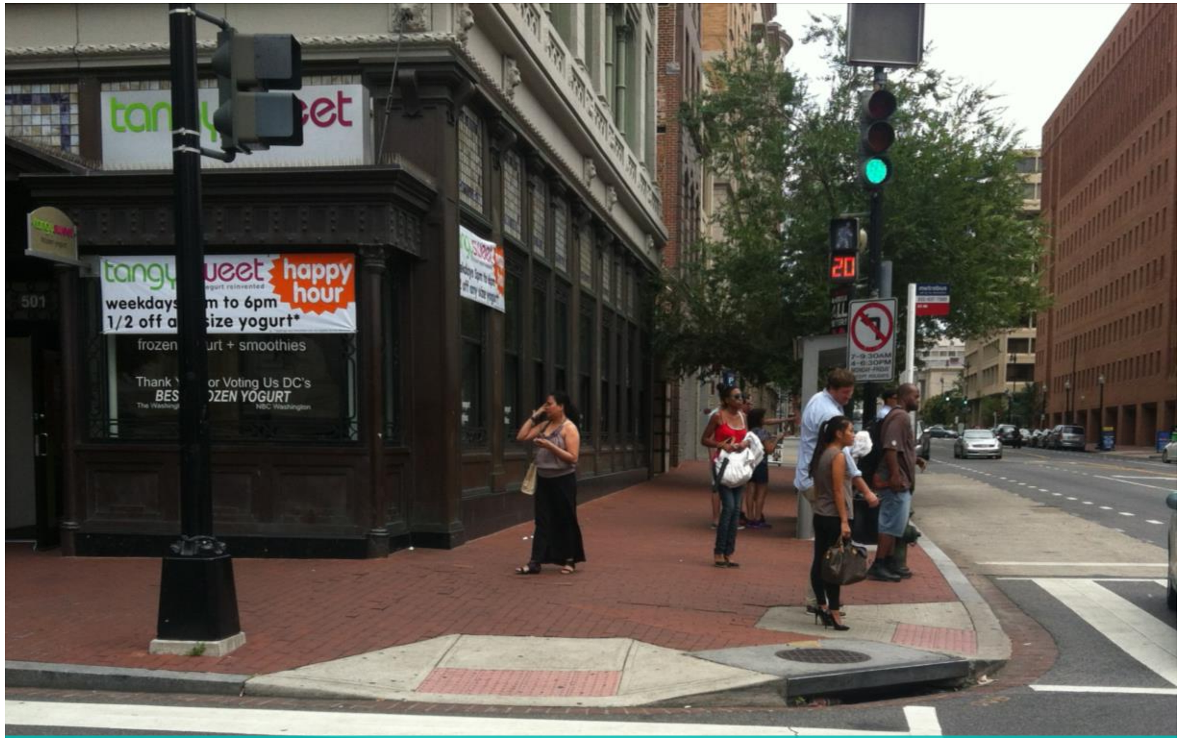
How well do accessibility problems found in Google Street View correspond with the real world?

IS GSV A GOOD DATASET FOR ACCESSIBILITY AUDITS?

PHYSICAL AUDITS VS. GOOGLE STREET VIEW

179 BUS STOPS

Washington DC & Seattle | 42 km surveyed



273 INTERSECTIONS

Washington DC & Baltimore | 34 km surveyed

COMPARISON RESULTS: SPEARMAN RANK COEFFICIENTS

BUS STOPS

PHYSICAL AUDIT DATA

VS.

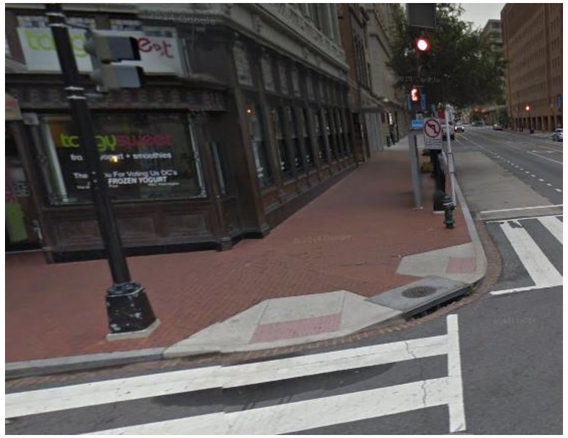
GSV AUDIT DATA

$$\rho = \mathbf{0.88}$$

INTERSECTIONS

PHYSICAL AUDIT DATA

VS.



GSV AUDIT DATA

$$\rho = \mathbf{0.98}$$

All results statistically significant at $p < 0.001$

IS GSV A GOOD DATASET FOR ACCESSIBILITY AUDITS?

CITY INFRASTRUCTURE CHANGES SLOWLY

AVG IMAGE AGE IN BUS STOP DATASET

1.7 yrs (SD=0.7)

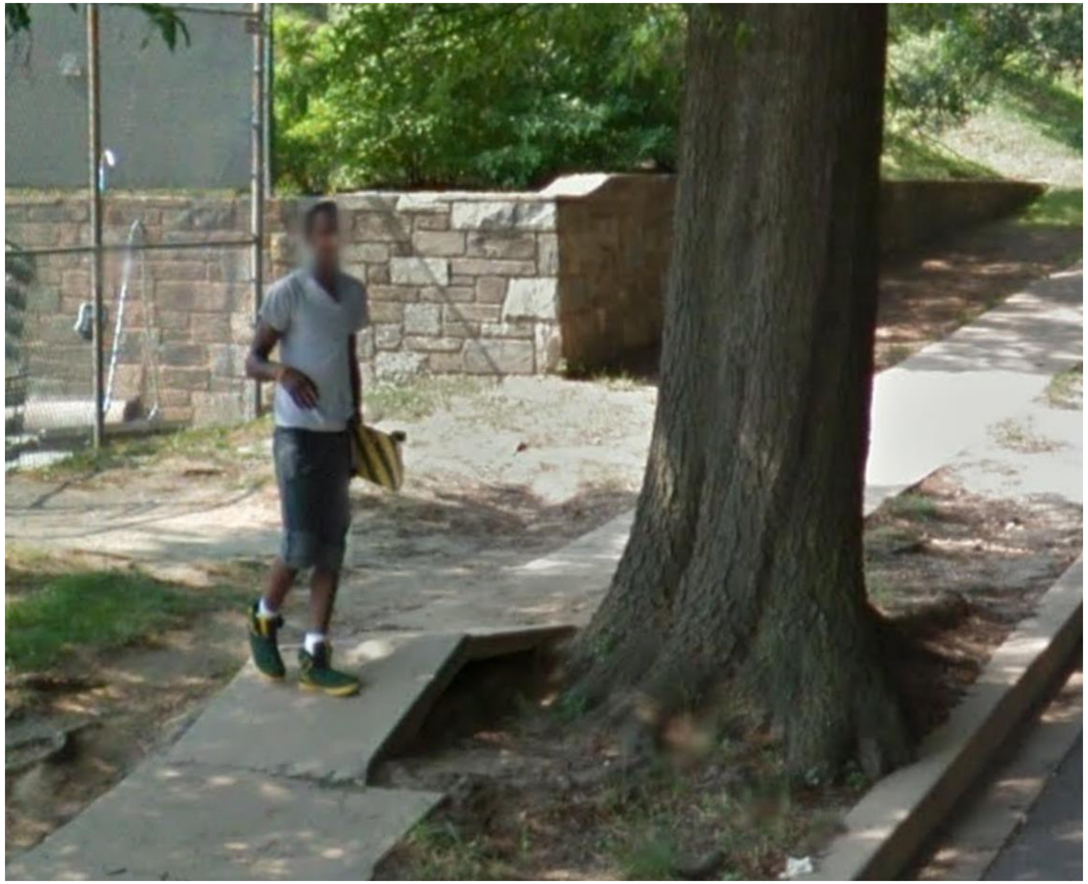
AVG IMAGE AGE IN INTERSECTION DATASET

1.5 yrs (SD=0.7)

Consistent with literature, see: Odgers *et al.,* 2012; Wilson *et al.,* 2013; Kelly *et al.,* 2013; Bader, *et al.,* 2017

Google Street View is a reasonable proxy for studying the state of street-level accessibility

KEY RESEARCH QUESTIONS



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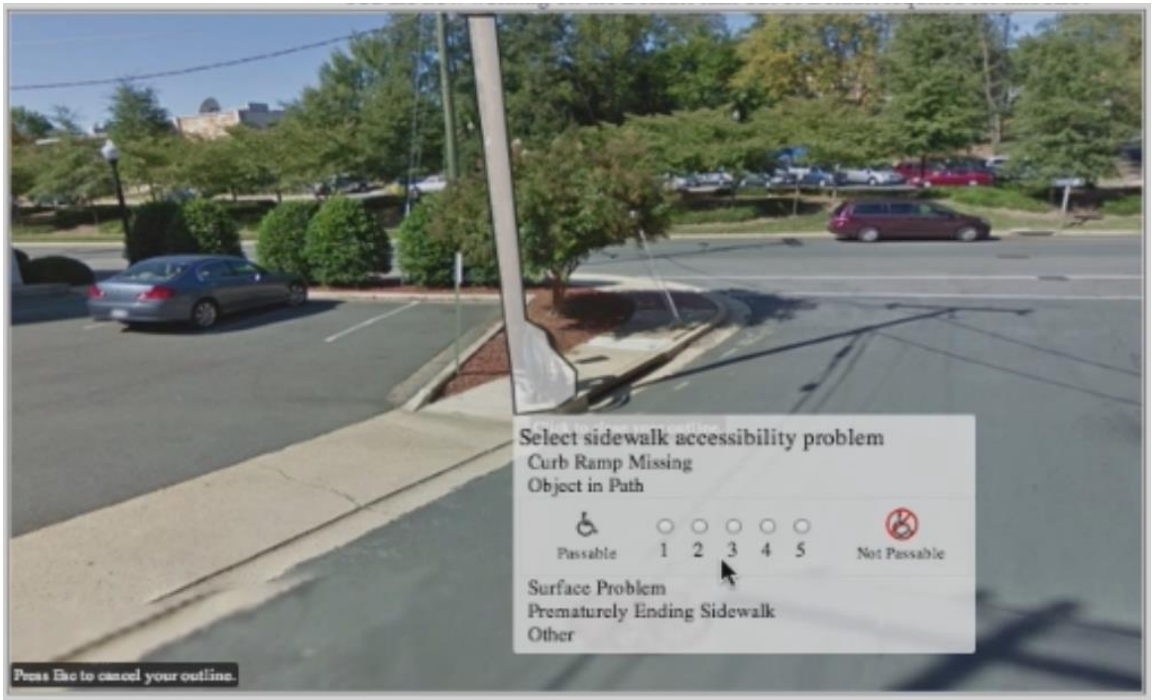
INITIAL CROWDSOURCING SYSTEM



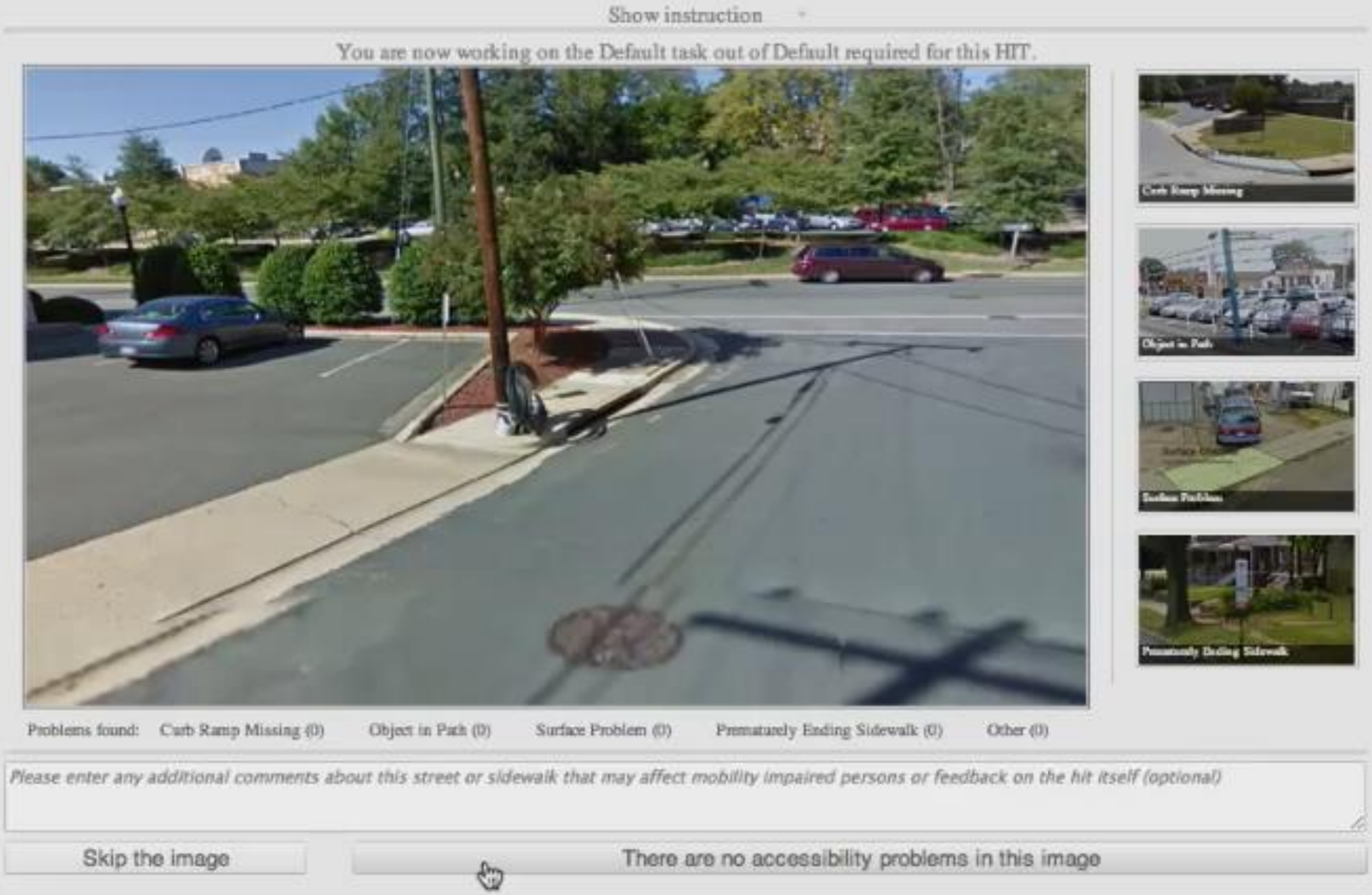
LABELING INTERFACE

VERIFICATION INTERFACE

LABELING INTERFACE

4-STEP PROCESS

1. Find & label problem

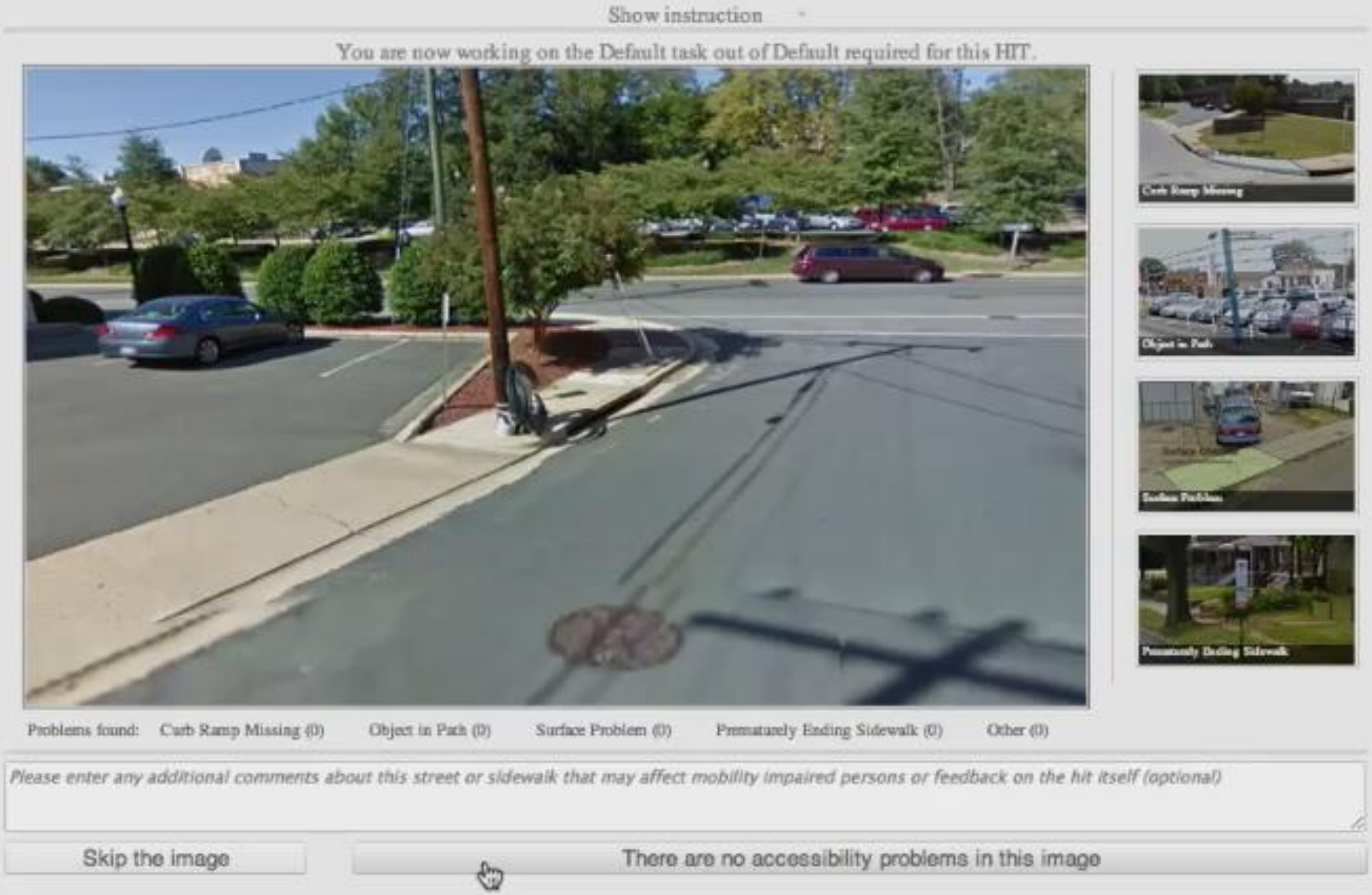


CROWDSOURCING ACCESSIBILITY AUDITS

LABELING INTERFACE

4-STEP PROCESS

1. Find & label problem

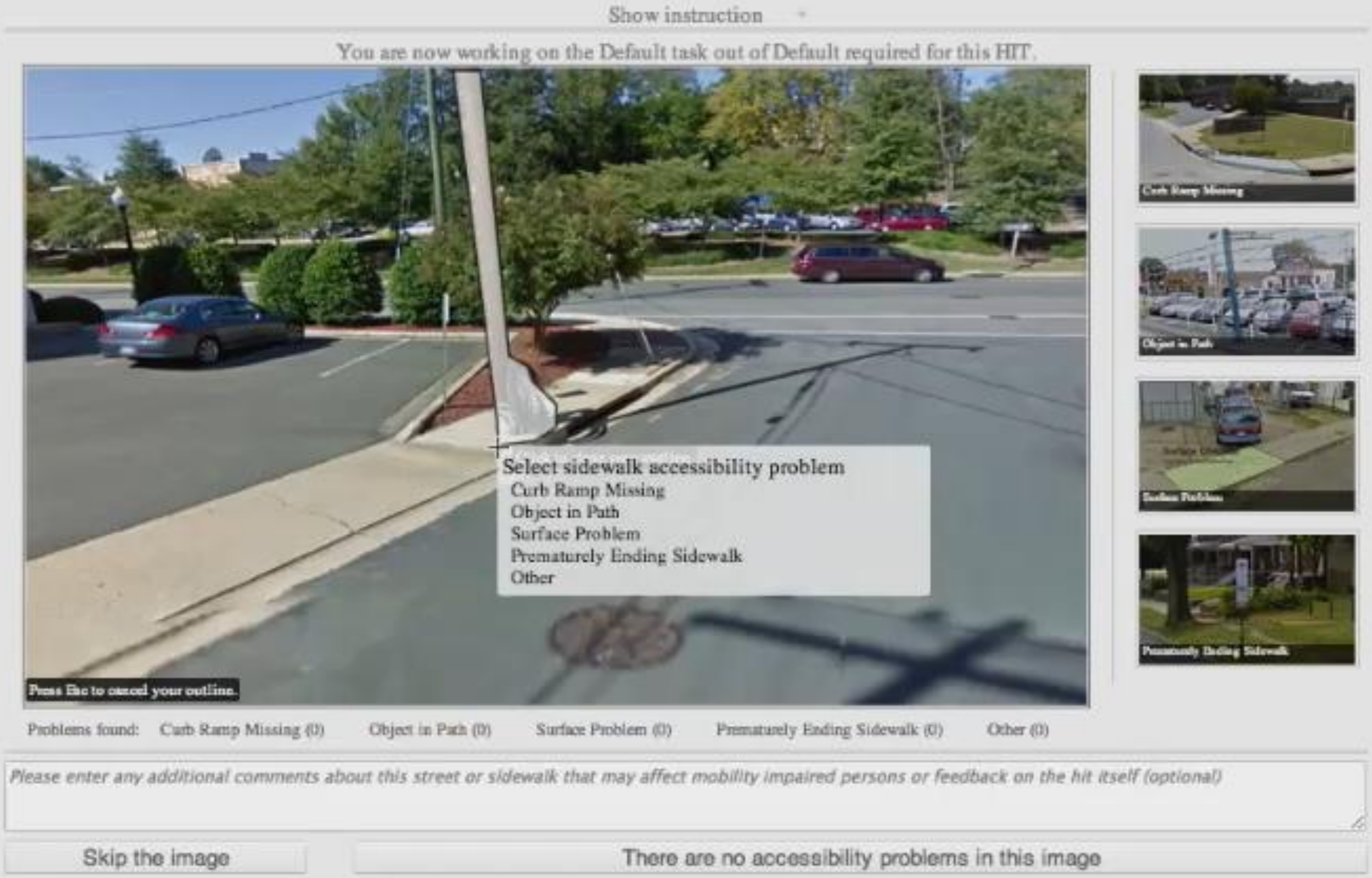


CROWDSOURCING ACCESSIBILITY AUDITS

LABELING INTERFACE

4-STEP PROCESS

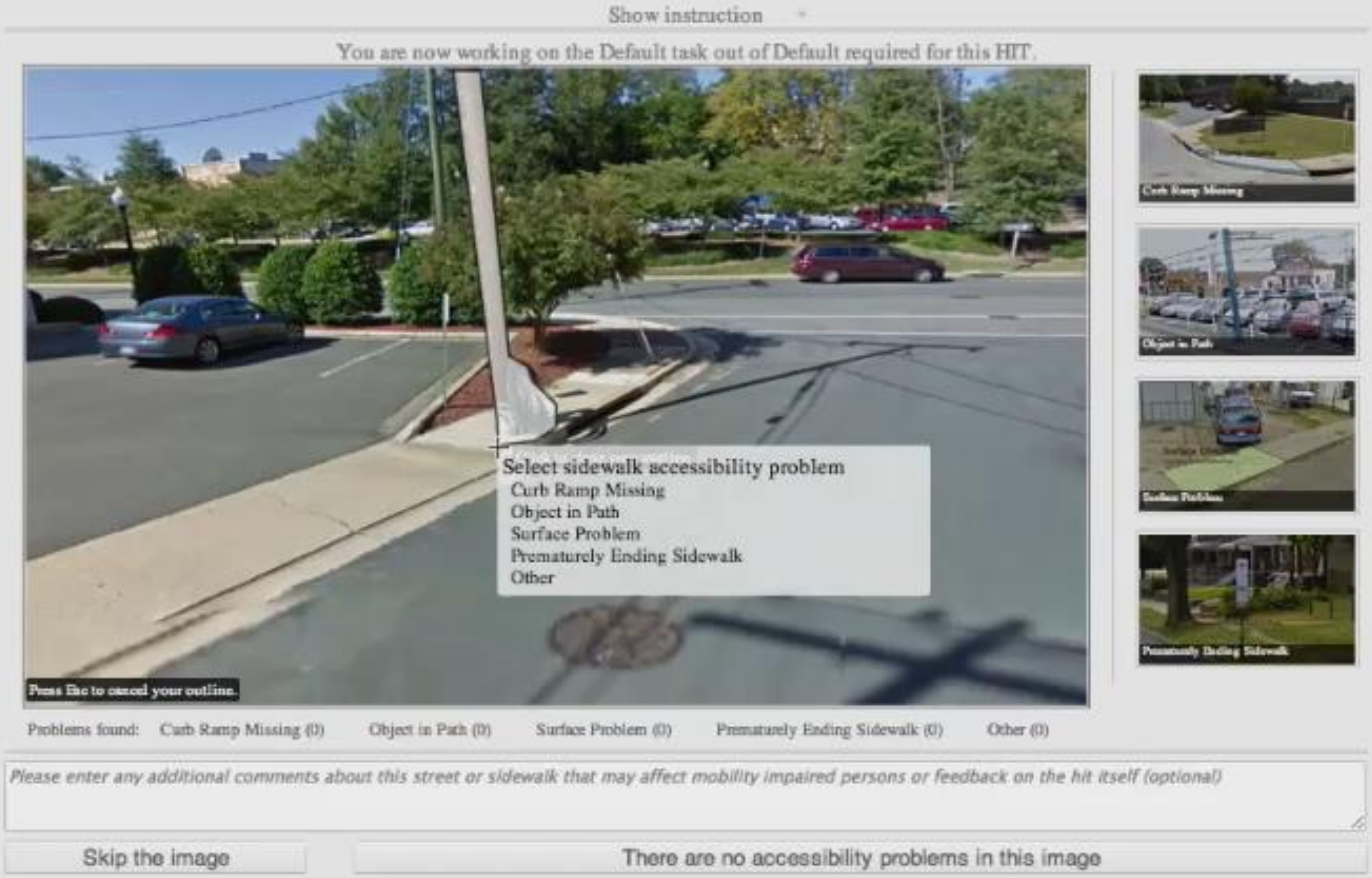
1. Find & label problem
2. Categorize problem



LABELING INTERFACE

4-STEP PROCESS

1. Find & label problem
2. Categorize problem



LABELING INTERFACE

4-STEP PROCESS

1. Find & label problem
2. Categorize problem
3. Rate problem severity

LABELING INTERFACE

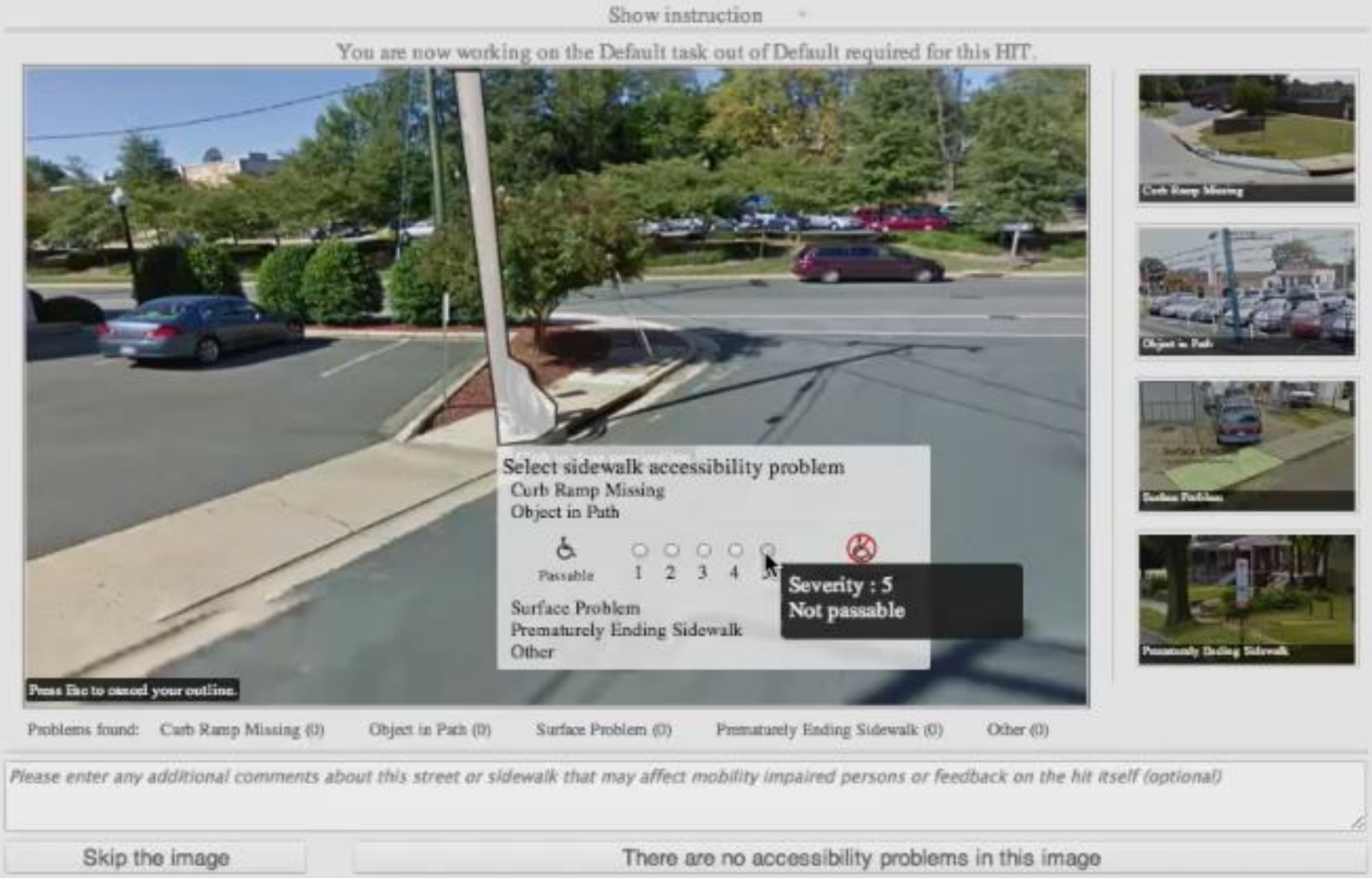
4-STEP PROCESS

1. Find & label problem
2. Categorize problem
3. Rate problem severity

LABELING INTERFACE

4-STEP PROCESS

1. Find & label problem
2. Categorize problem
3. Rate problem severity
4. Submit work



CROWDSOURCING ACCESSIBILITY AUDITS
LABELING INTERFACE

4-STEP PROCESS
1. Find & label problem
2. Categorize problem
3. Rate problem severity
4. Submit work

Receive another image to label & process repeats.

VERIFICATION INTERFACE

3-STEP PROCESS

1. Verify label
2. Verify rating
3. Provide details

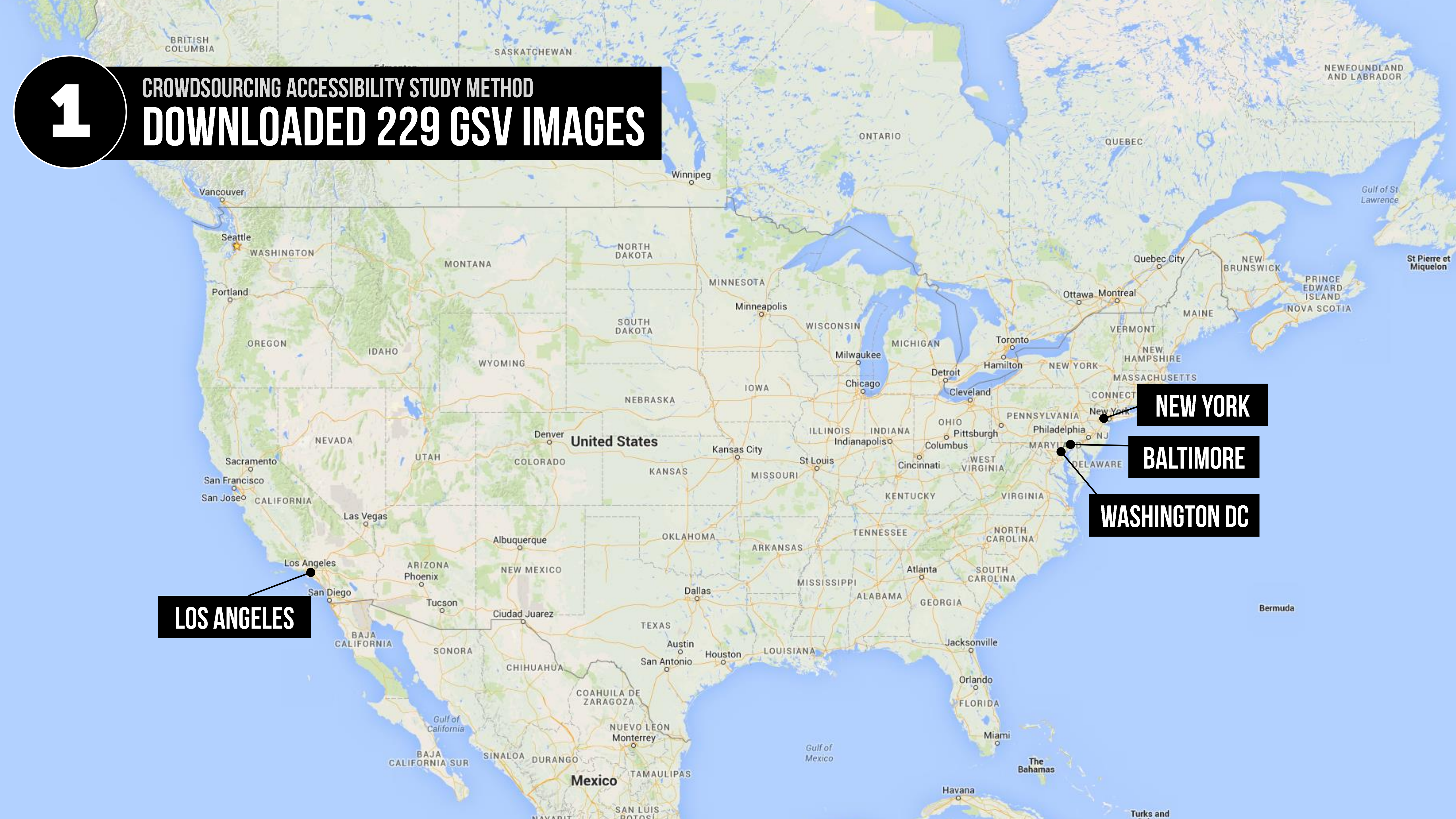
STUDY METHOD

1. Create image dataset
2. Generate ground truth labels
3. Deploy our tools to crowd
4. Compare performance to ground truth

1

CROWDSOURCING ACCESSIBILITY STUDY METHOD

DOWNLOADED 229 GSV IMAGES



50 images
Sidewalk Ending

66 images
Object in Path

67 images
Surface Problems

47 images
Missing Curb Ramps

50 images
No Problems

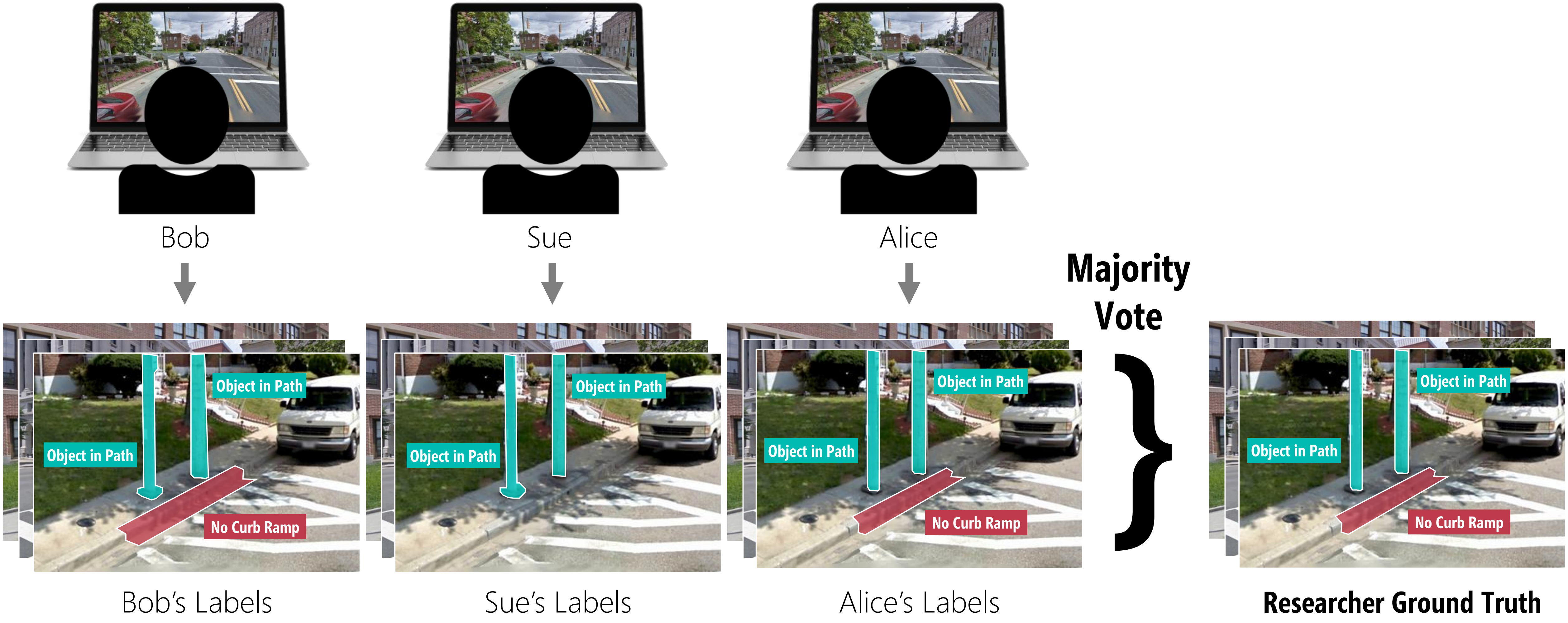
STUDY METHOD

1. Create image dataset

2. Generate ground truth labels

CROWDSOURCING ACCESSIBILITY STUDY METHOD

2 CREATE GROUND TRUTH LABELS



STUDY METHOD

1. Create image dataset
2. Generate ground truth labels
3. Deploy our tools to crowd

3

CROWDSOURCING ACCESSIBILITY STUDY METHOD

DEPLOY TOOLS TO MECHANICAL TURK

amazon

mechanical turk

CROWDSOURCING ACCESSIBILITY STUDY RESULTS

MTURK STUDY STATISTICS

185
LABELERS

7,517
LABELS

35.2s
LABEL AN IMAGE

273
VERIFIERS

19,189
VERIFICATIONS

3x as fast!

10.5s
VERIFY AN IMAGE

STUDY METHOD

1. Create image dataset
2. Generate ground truth labels
3. Deploy our tools to crowd
4. Compare performance to ground truth

Are crowd workers capable of **finding accessibility problems** in online map imagery?

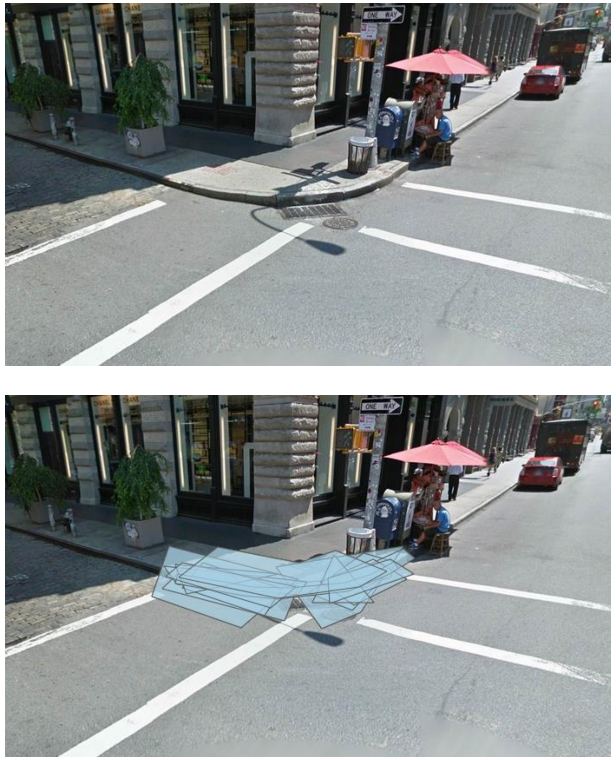
CROWDSOURCING ACCESSIBILITY STUDY RESULTS

OVERALL LABELING ACCURACY

With one labeler per image

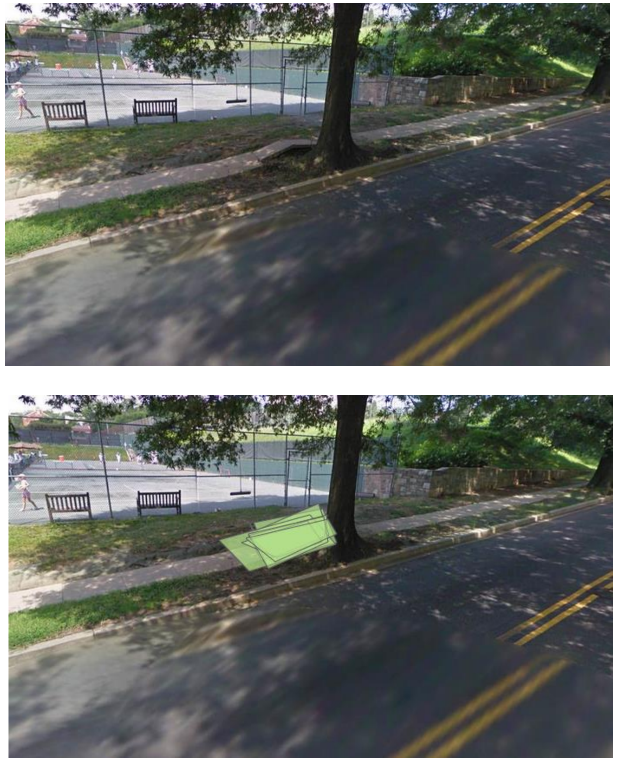
SIDEWALK ENDING

85%



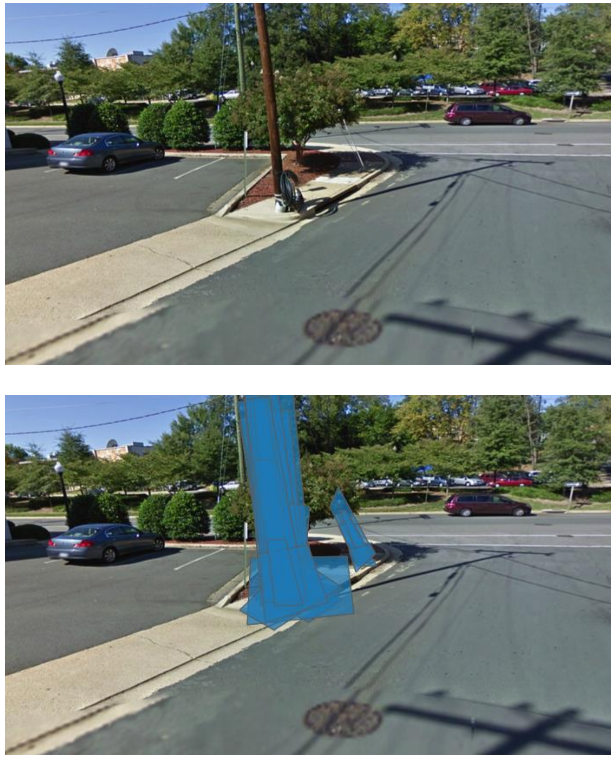
MISSING CURB RAMPS

79%



SURFACE PROBLEM

77%



OBJECT IN PATH

73%

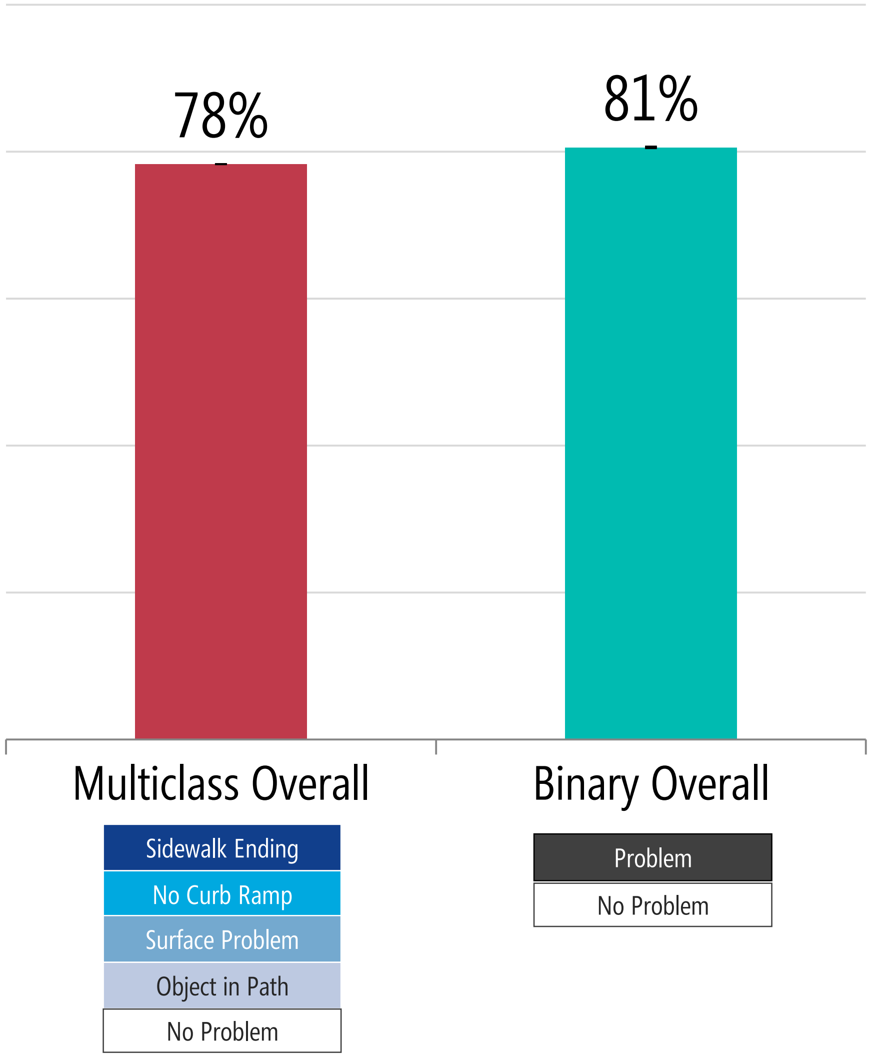
CROWDSOURCING ACCESSIBILITY STUDY RESULTS

OVERALL LABELING ACCURACY

With one labeler per image

SIDEWALK ENDING	MISSING CURB RAMPS	SURFACE PROBLEM	OBJECT IN PATH
85%	**79%**	**77%**	**73%**

AVERAGE OVERALL ACCURACY



CROWDSOURCING ACCESSIBILITY STUDY RESULTS

COMMON LABELER MISTAKES

OVER LABELING

(*i.e.,* tendency towards false positives)

RANDOM LABELS

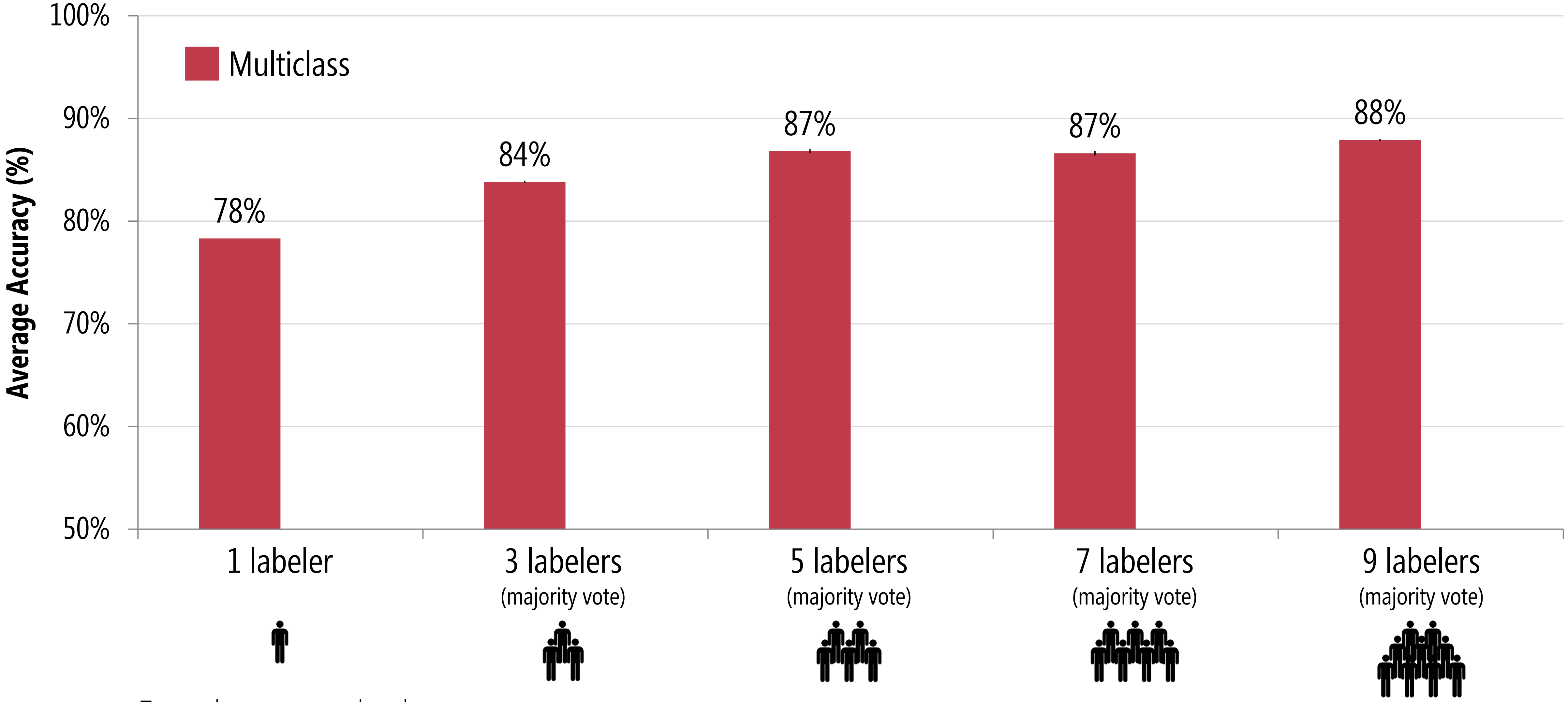
(*e.g.,* misunderstanding, malevolence)

CATEGORY ERRORS

(*i.e.,* ambiguous problem category)

CROWDSOURCING ACCESSIBILITY STUDY RESULTS

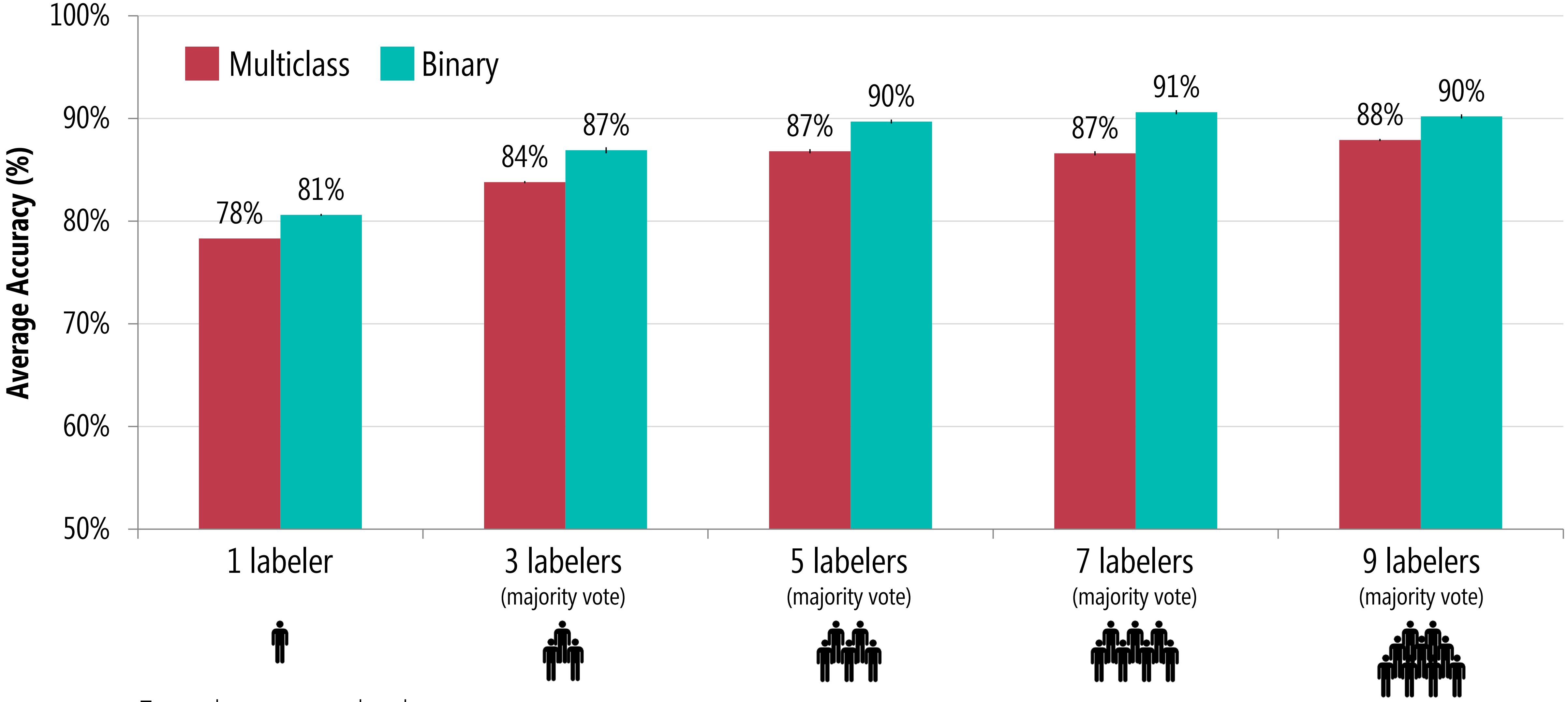
ACCURACY AS A FUNCTION OF LABELERS PER IMAGE



Error bars: standard error

CROWDSOURCING ACCESSIBILITY STUDY RESULTS

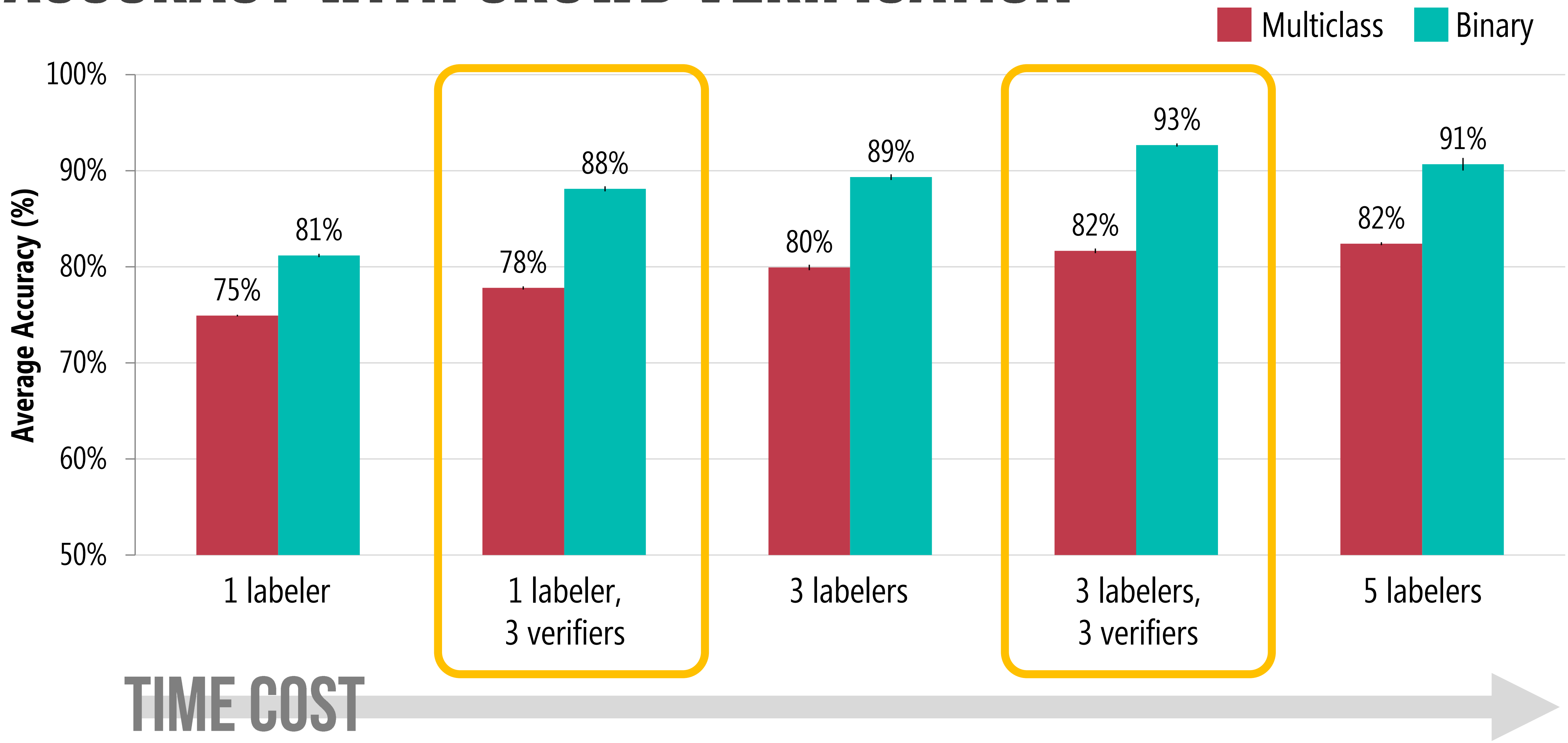
ACCURACY AS A FUNCTION OF LABELERS PER IMAGE



Error bars: standard error

CROWDSOURCING ACCESSIBILITY STUDY RESULTS

ACCURACY WITH CROWD VERIFICATION

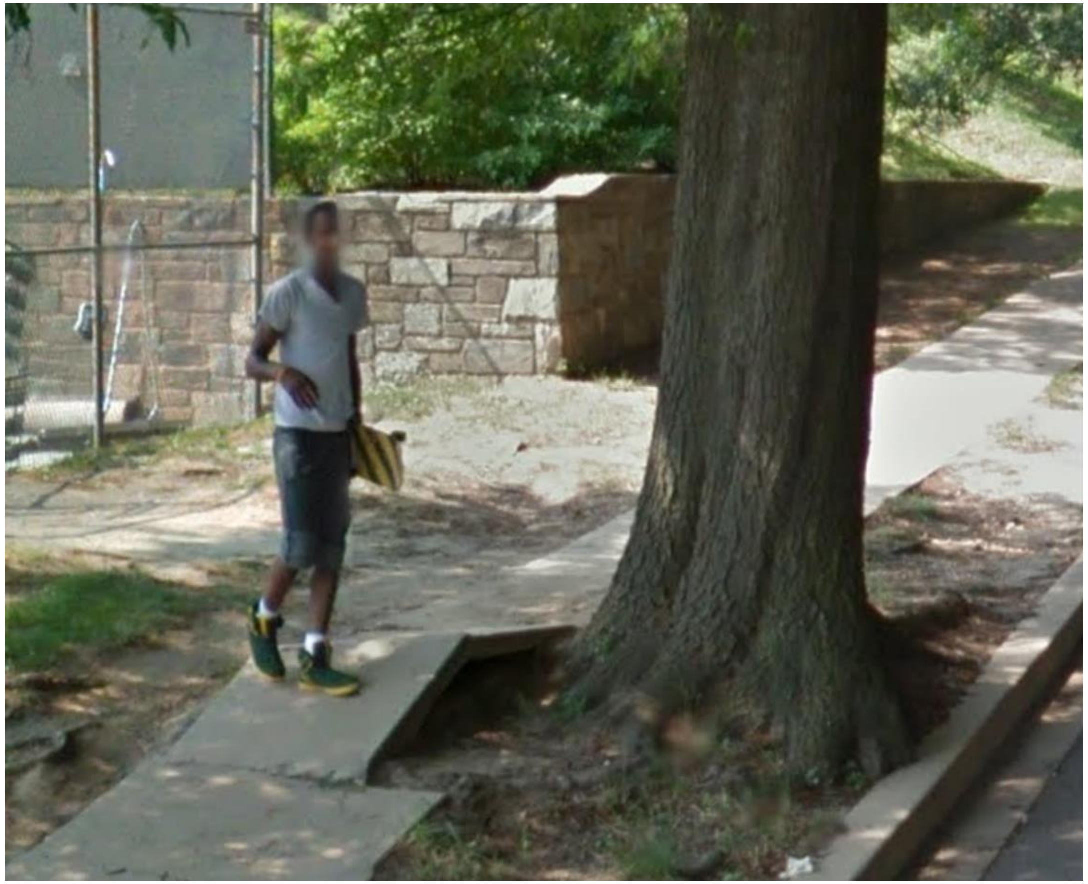


Error bars: standard error; experiments run on subset of data

With basic quality control measures, **minimally trained crowd** workers can find accessibility problems with an accuracy of **~93%**

Relied **purely on manual labor**. Can we do better?

KEY RESEARCH QUESTIONS



SCALABLE DATA COLLECTION METHODS

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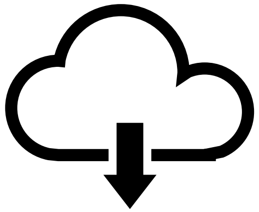
Tohme

遠目 ·*Remote Eye*

1 svCrawl
Web Scraper



TOHME
遠目 Remote Eye

1 svCrawl
Web Scraper

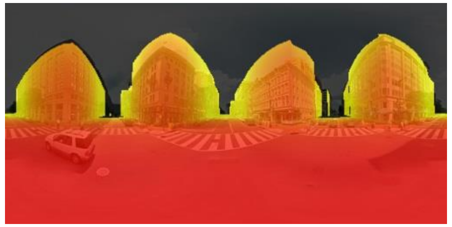
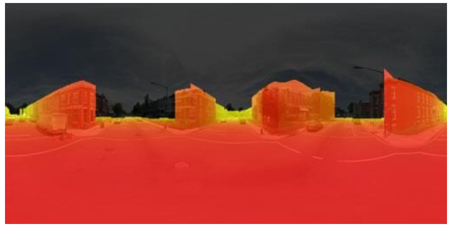
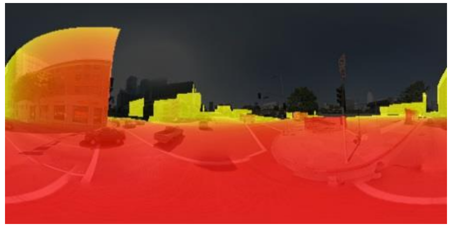
Street View images
3D-depth maps
Top-down map images
GIS metadata

2 **Street Dataset**

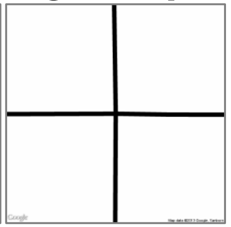
Google Street View Panoramas

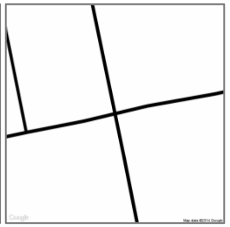


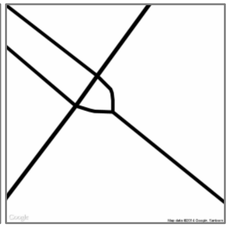
3D Point-cloud Data

Top-down Google Maps Imagery



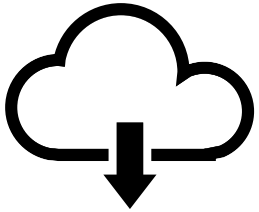


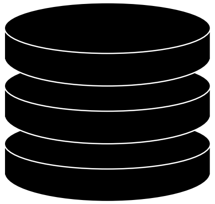
GIS Metadata

<Latitude & longitude/>
<GSV image age/>
<Street & city names/>
<Intersection topology/>

TOHME
遠目 Remote Eye

1 svCrawl
Web Scraper

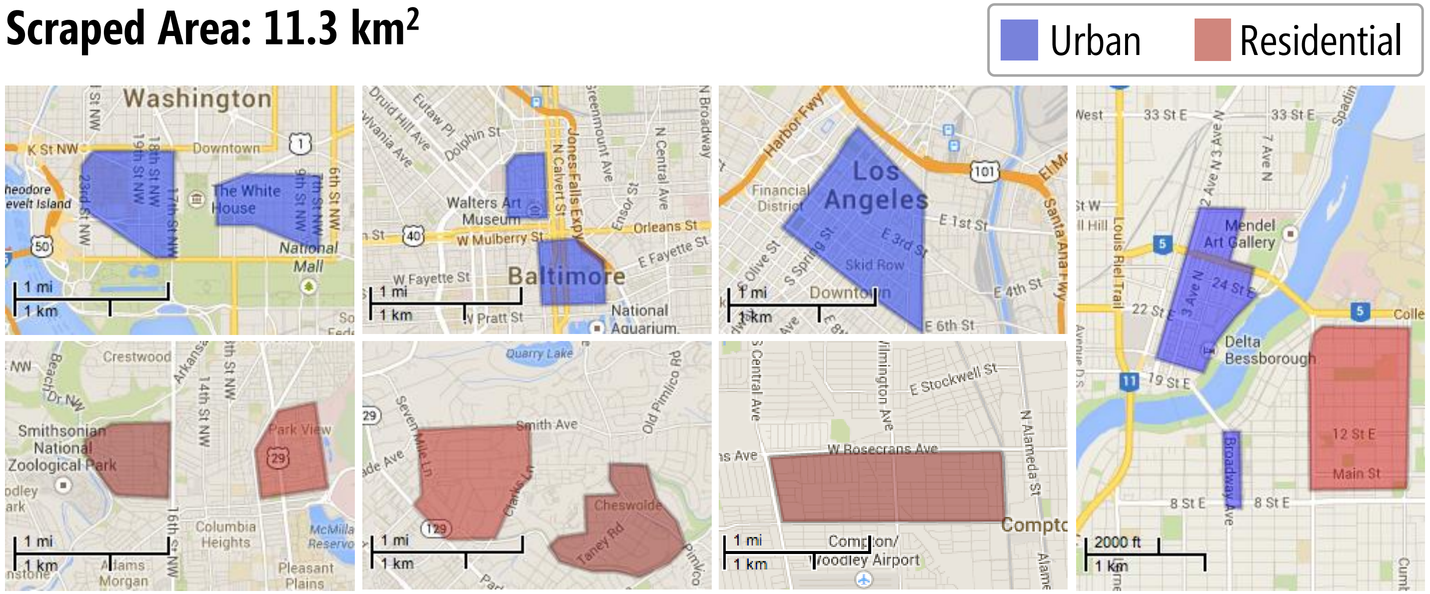




Street View images
3D-depth maps
Top-down map images
GIS metadata

2 **Street Dataset**

Scraped Area: 11.3 km²



D.C.   Baltimore   Los Angeles   Saskatoon

Dataset Statistics

1,086
intersections

2,877
curb ramps

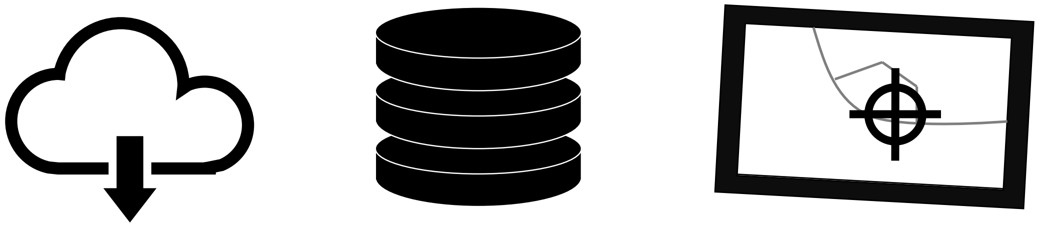
647
missing curb ramps

2.2 yrs (SD=1.3)
average GSV image age

TOHME
遠目 Remote Eye

1 svCrawl
Web Scraper

3 svDetect
Automatic Curb Ramp Detection



Street View images
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TOHME
遠目 Remote Eye

1 svCrawl
Web Scraper

2 **Street Dataset**
Street View images
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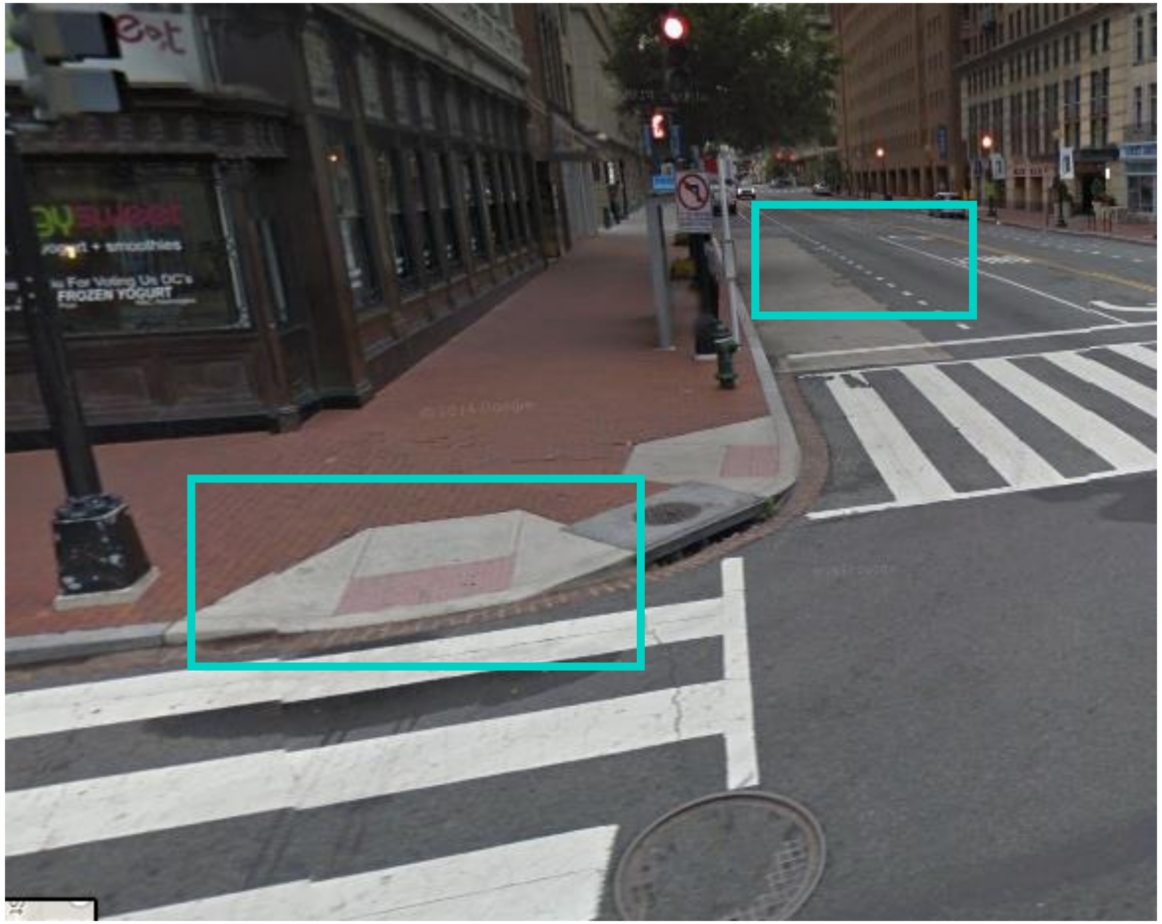
3 svDetect
Automatic Curb Ramp Detection

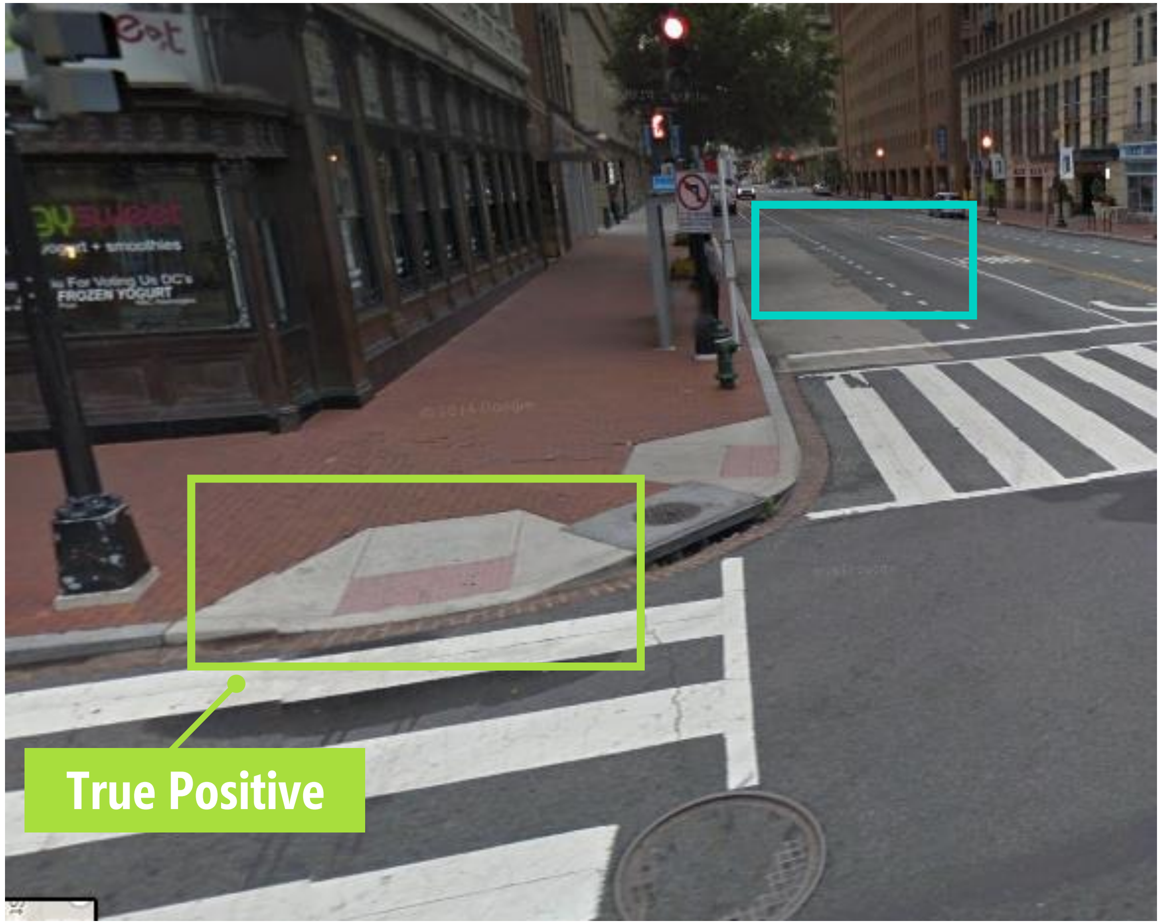


TOHME
遠目 Remote Eye

1 svCrawl
Web Scraper

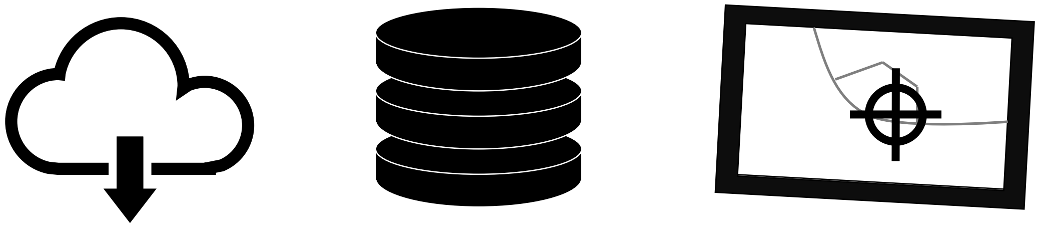
3 svDetect
Automatic Curb Ramp Detection

2 **Street Dataset**
Street View images
3D-depth maps
Top-down map images
GIS metadata



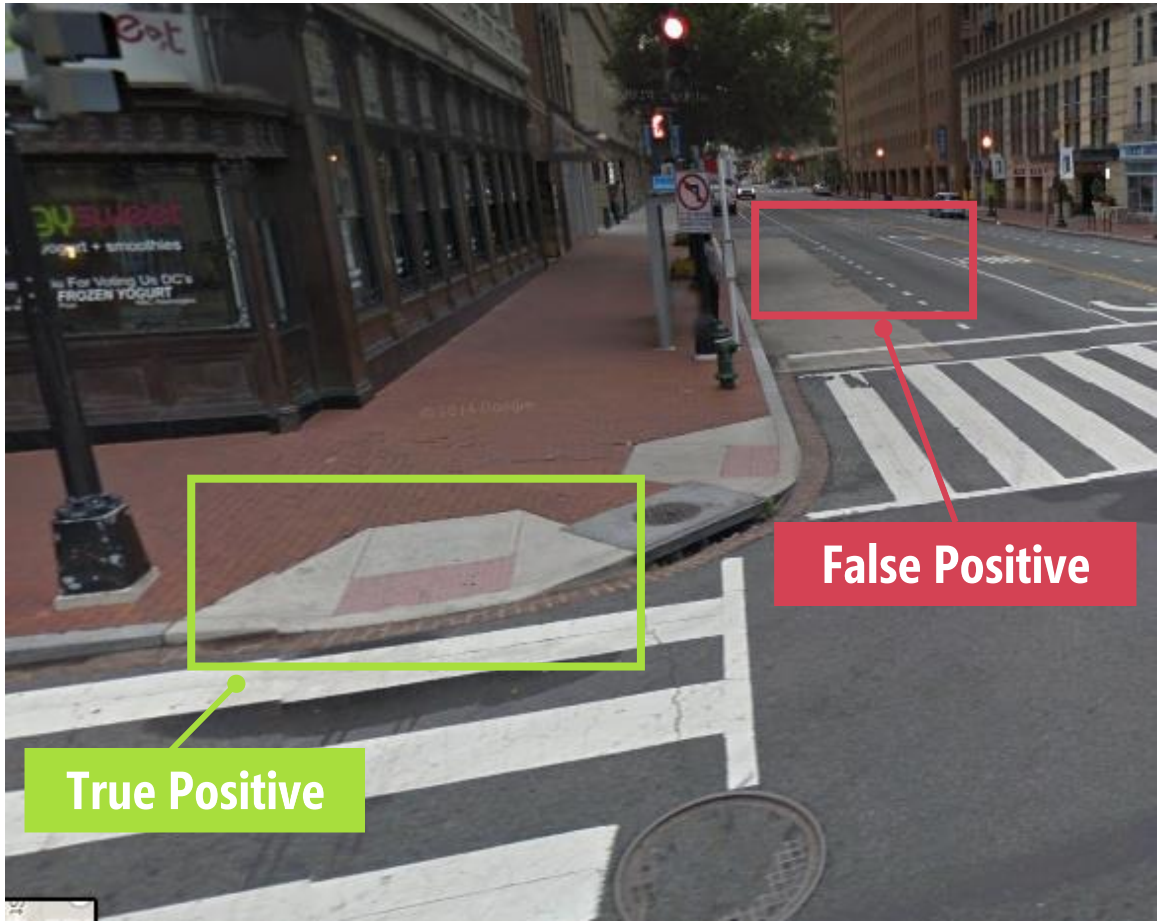
1 svCrawl
Web Scraper

3 svDetect
Automatic Curb Ramp Detection



Street View images
3D-depth maps
Top-down map images
GIS metadata

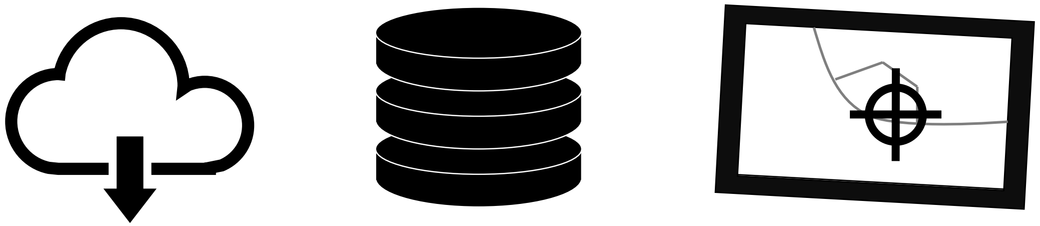
2 **Street Dataset**



TOHME
遠目 Remote Eye

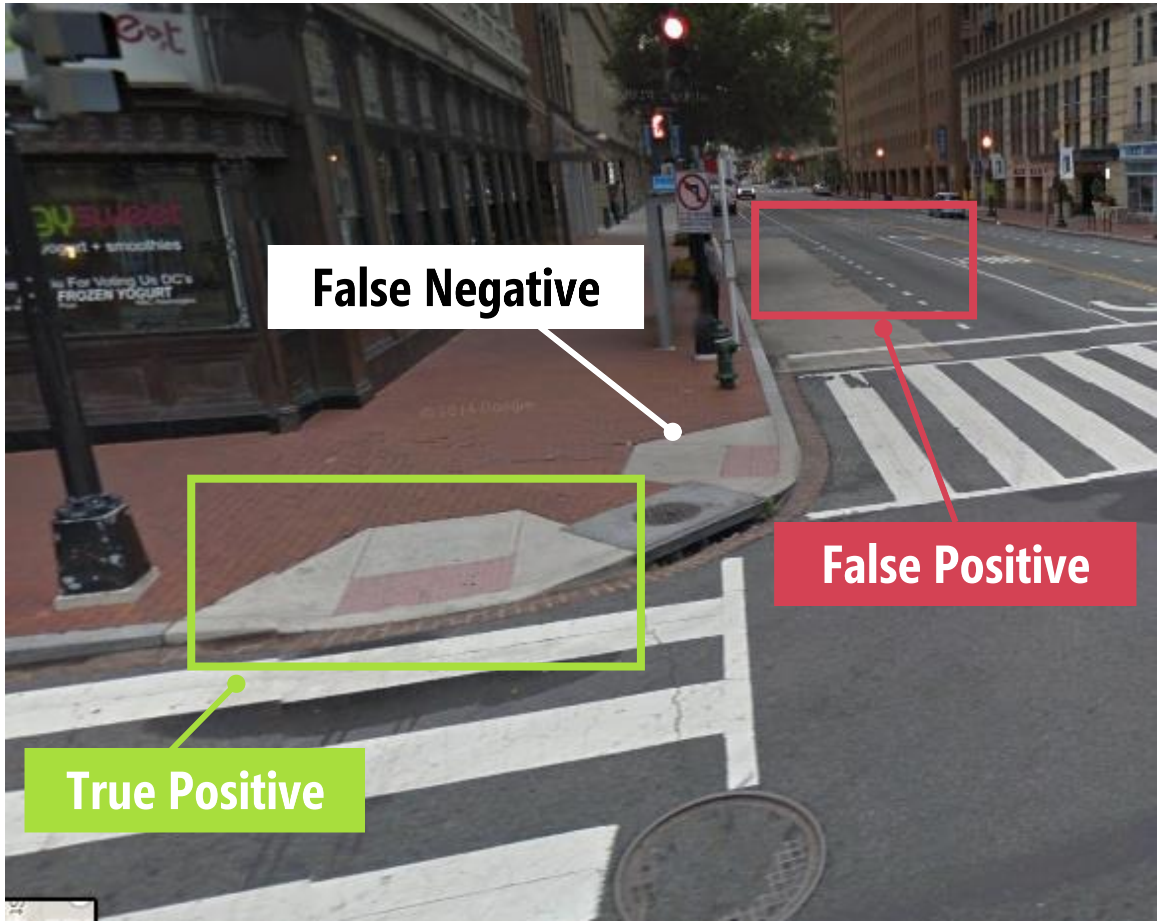
1 svCrawl
Web Scraper

3 svDetect
Automatic Curb Ramp Detection

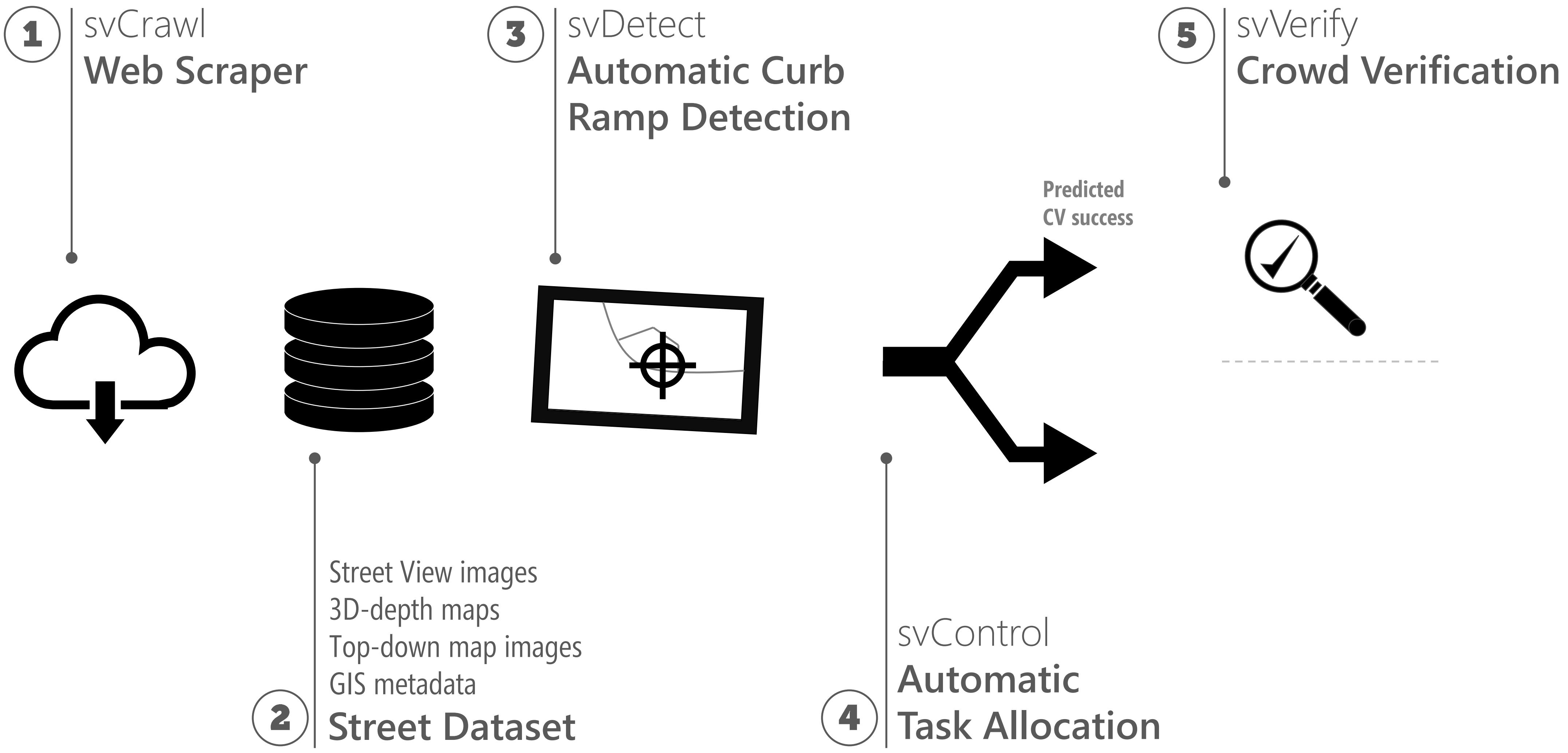


Street View images
3D-depth maps
Top-down map images
GIS metadata

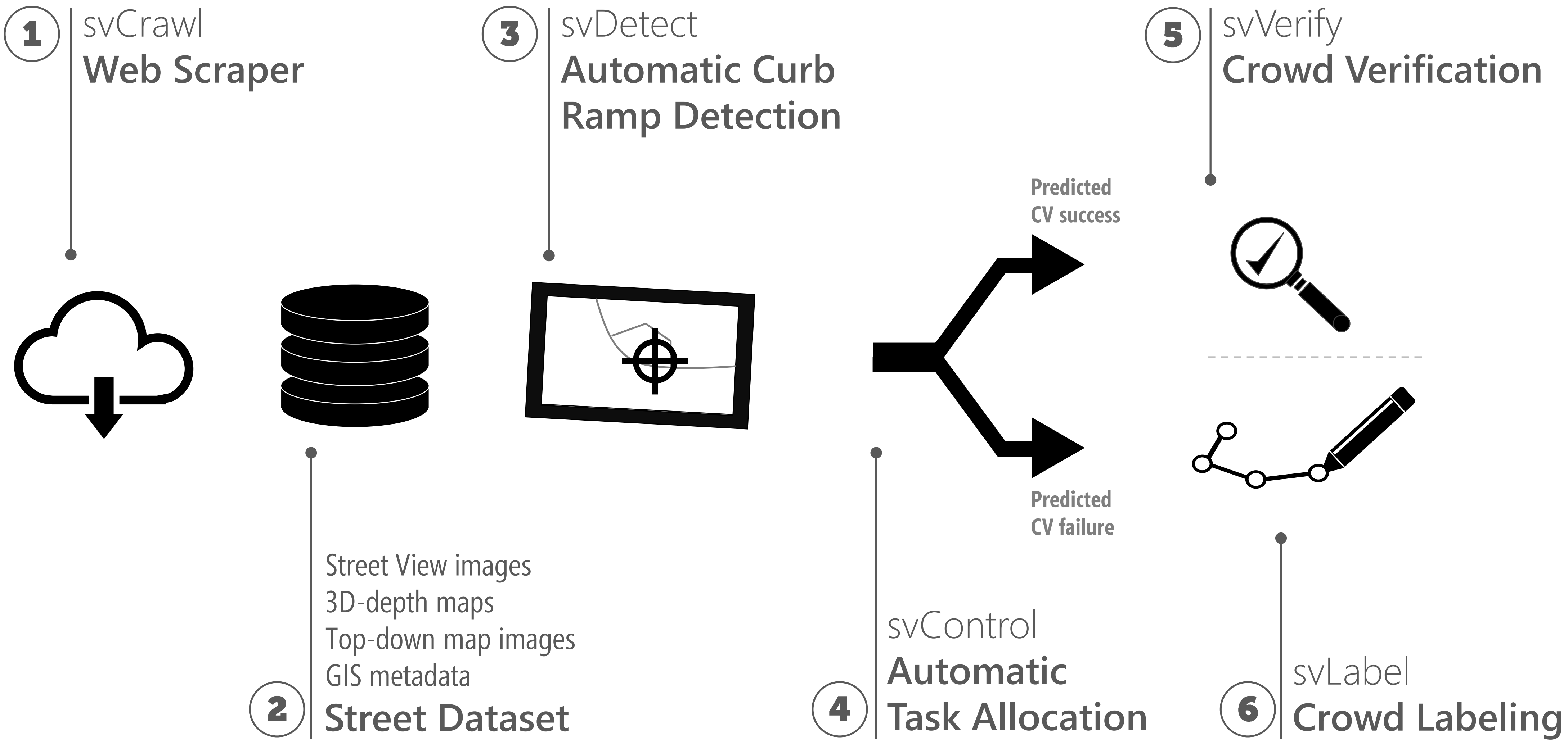
2 **Street Dataset**



TOHME
遠目 Remote Eye



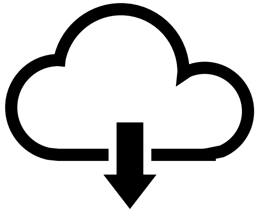
TOHME
遠目 Remote Eye

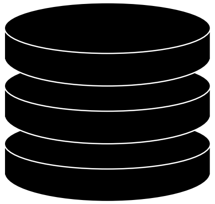


TOHME

遠目 Remote Eye

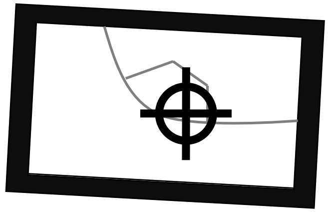
1 svCrawl
Web Scraper

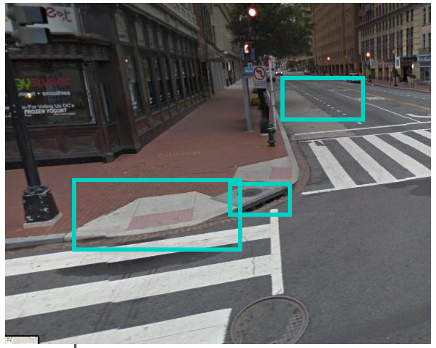




2
Street View images
3D-depth maps
Top-down map images
GIS metadata
Street Dataset

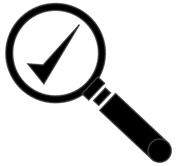
3 svDetect
Automatic Curb Ramp Detection



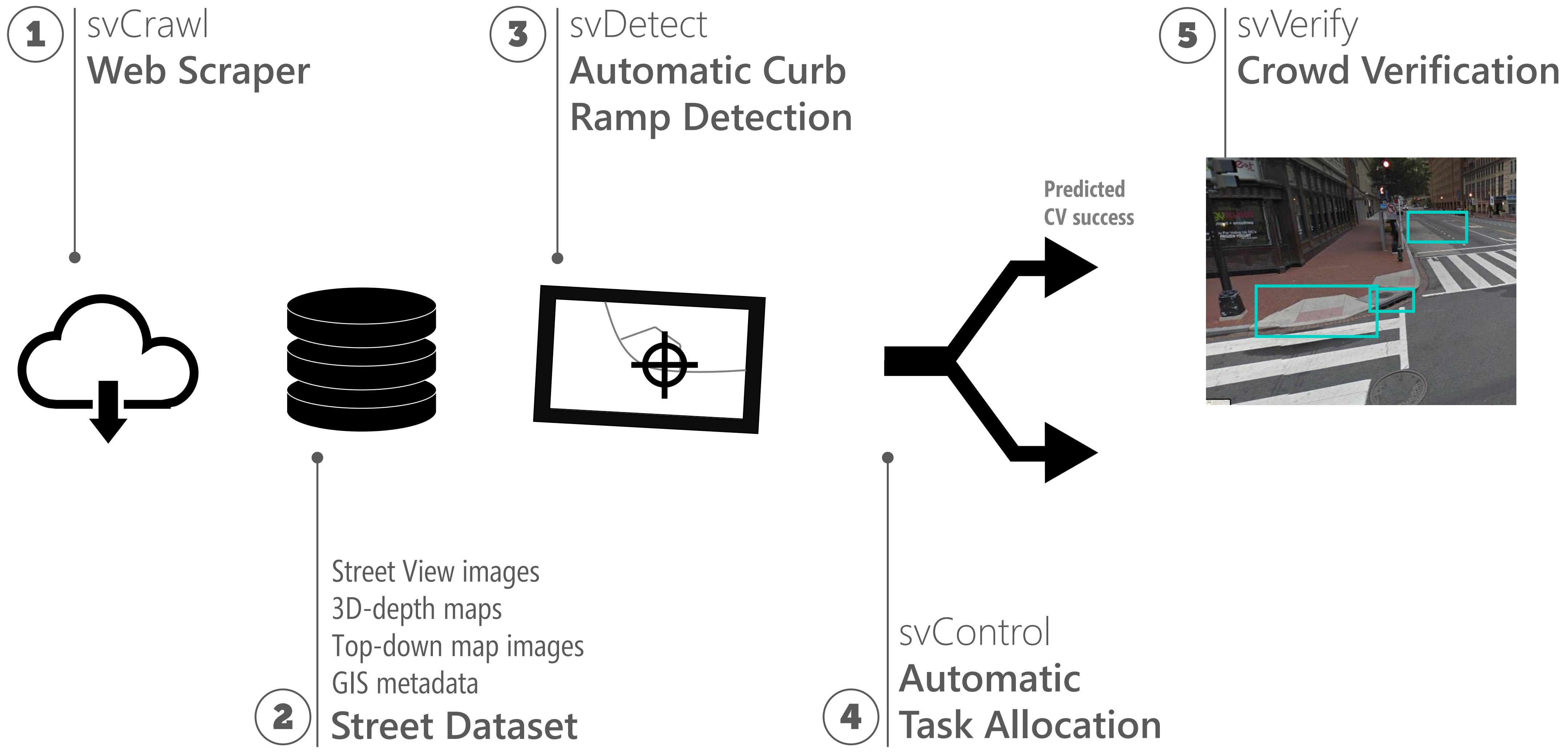


4 svControl
Automatic Task Allocation

5 svVerify
Crowd Verification



TOHME
遠目 Remote Eye

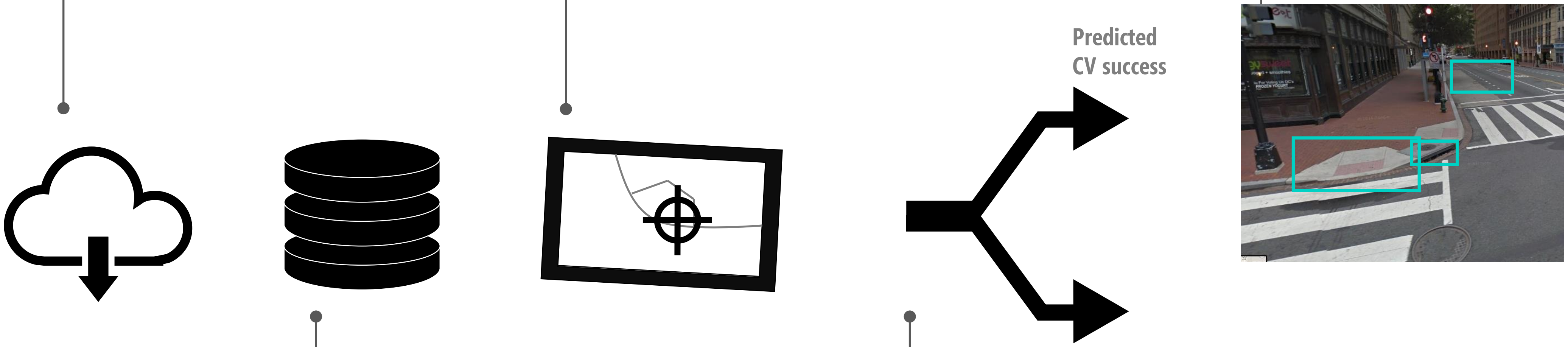


TOHME
遠目 Remote Eye

1 svCrawl
Web Scraper

3 svDetect
Automatic Curb Ramp Detection

5 svVerify
Crowd Verification

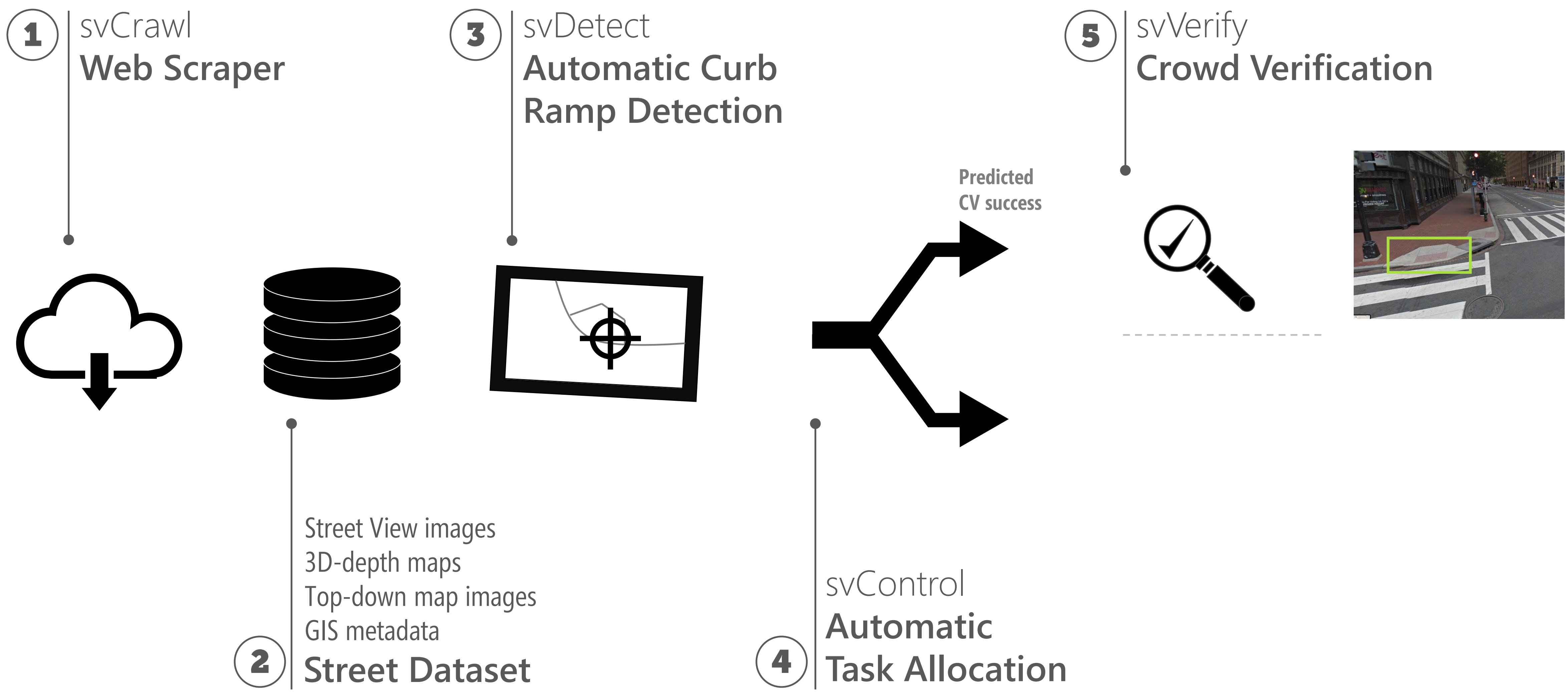


2
Street View images
3D-depth maps
Top-down map images
GIS metadata
Street Dataset

4 svControl
Automatic Task Allocation

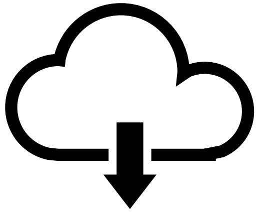
TOHME

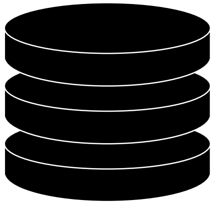
遠目 Remote Eye



TOHME
遠目 Remote Eye

1 svCrawl
Web Scraper

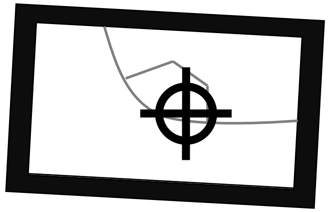


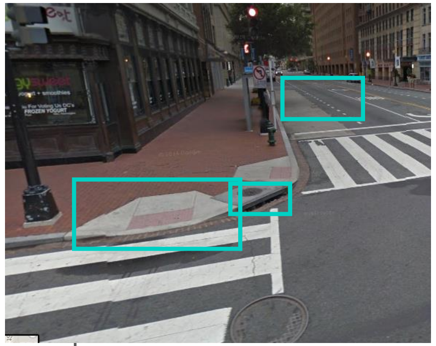


Street View images
3D-depth maps
Top-down map images
GIS metadata

2 **Street Dataset**

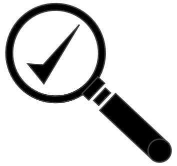
3 svDetect
Automatic Curb Ramp Detection

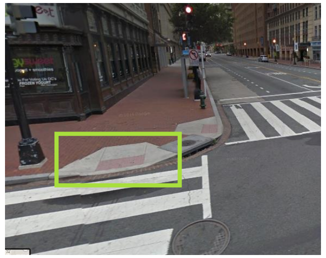


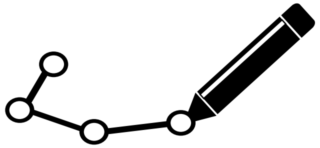


4 svControl
Automatic Task Allocation

5 svVerify
Crowd Verification

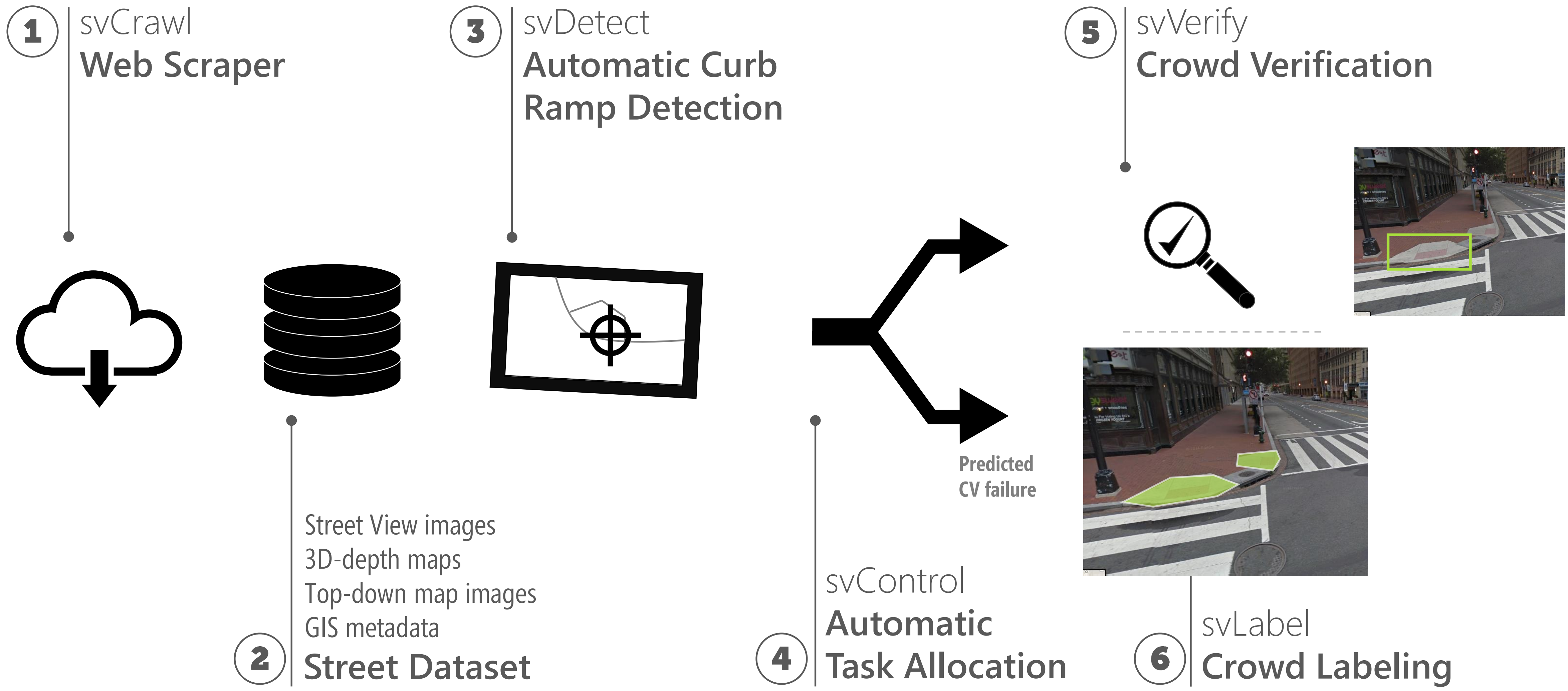




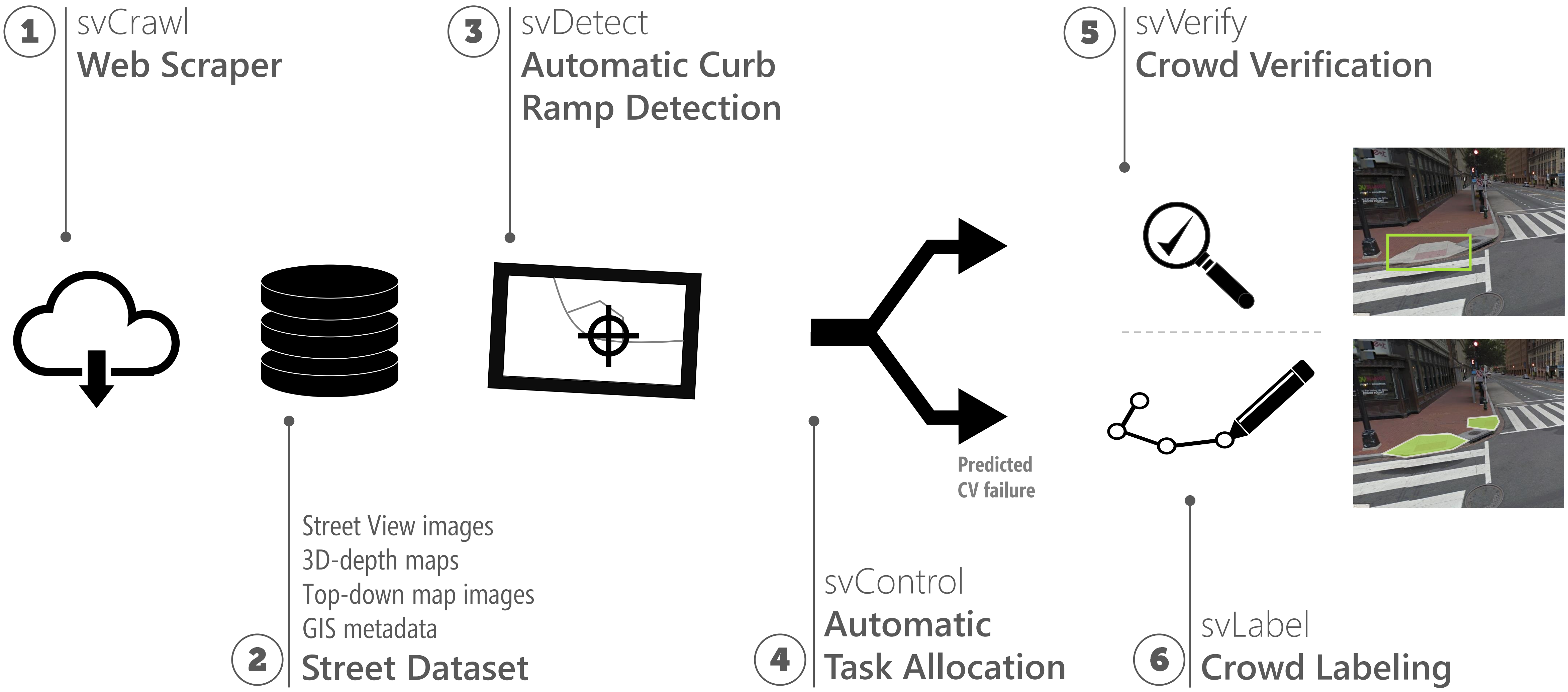


6 svLabel
Crowd Labeling

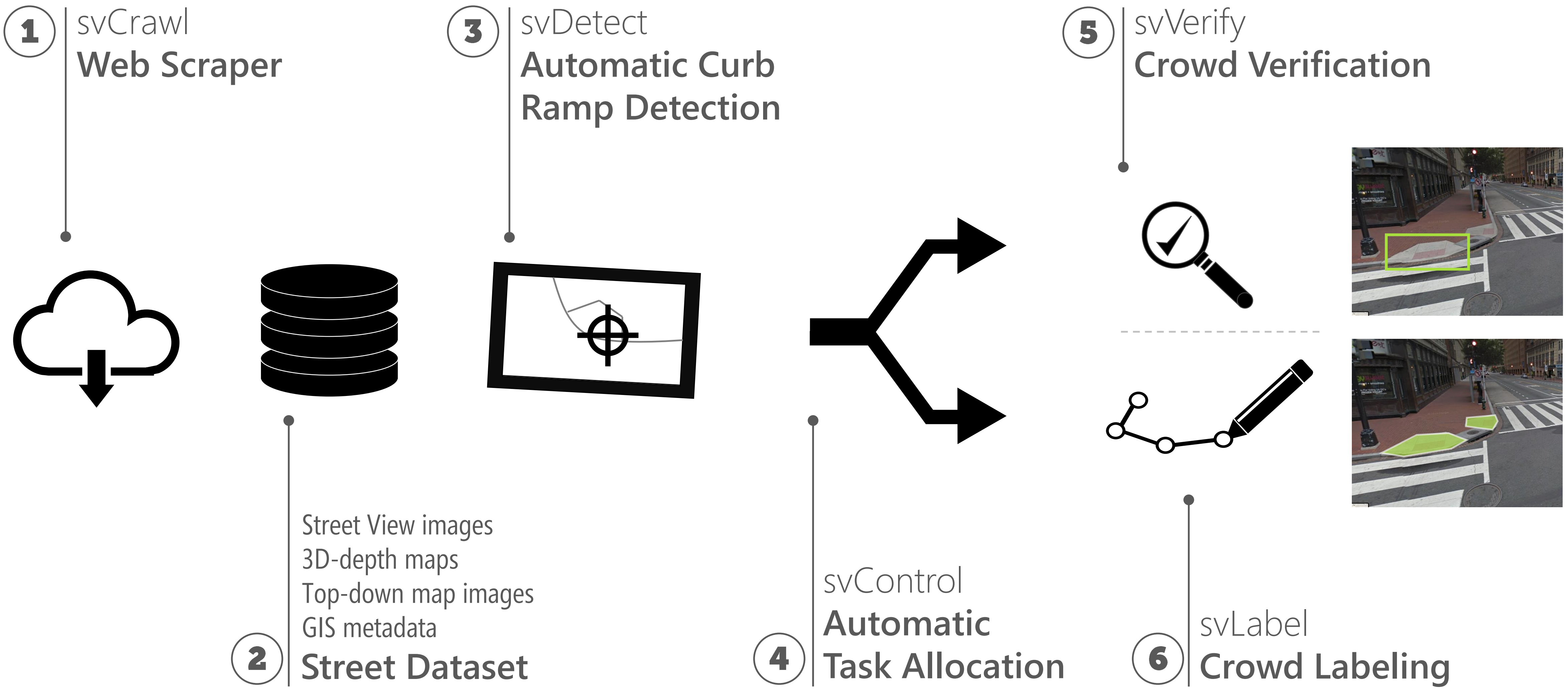
TOHME
遠目 Remote Eye

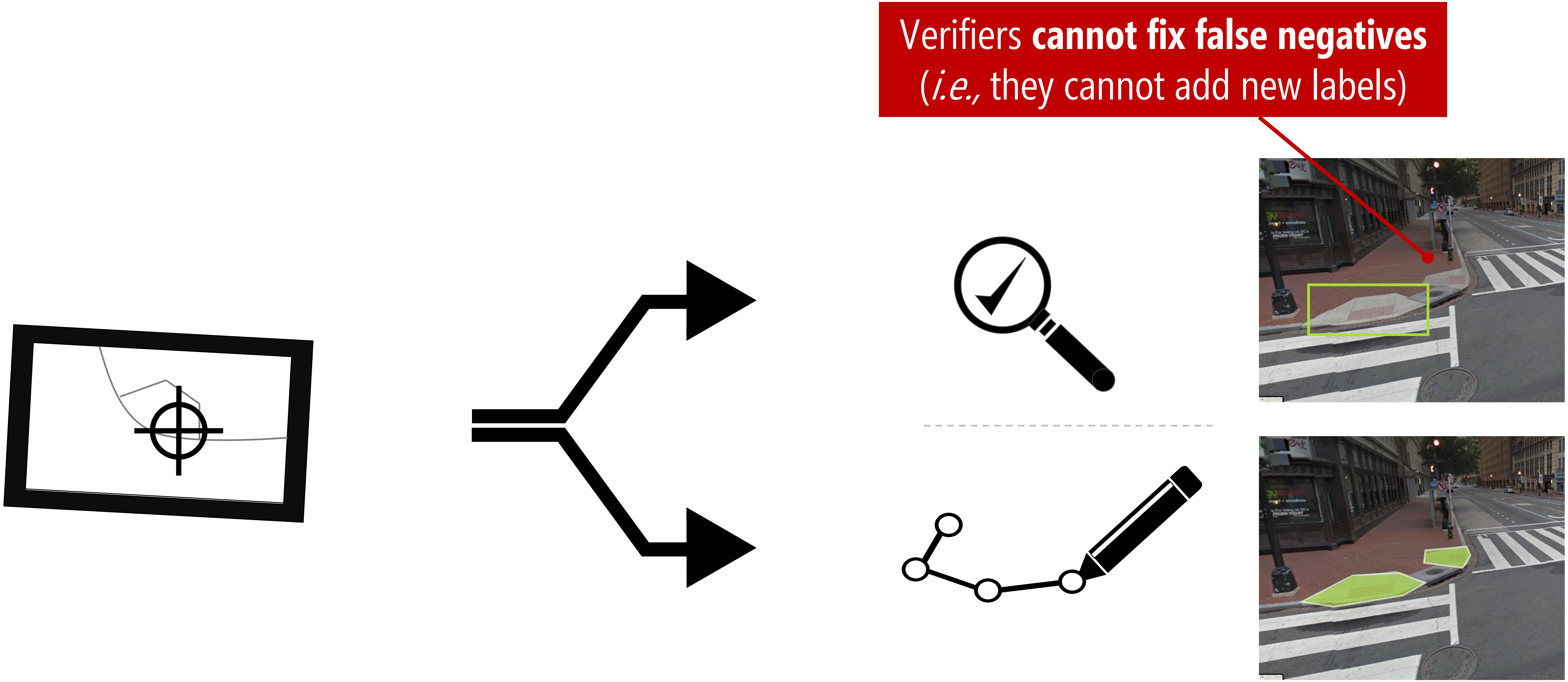


TOHME
遠目 Remote Eye



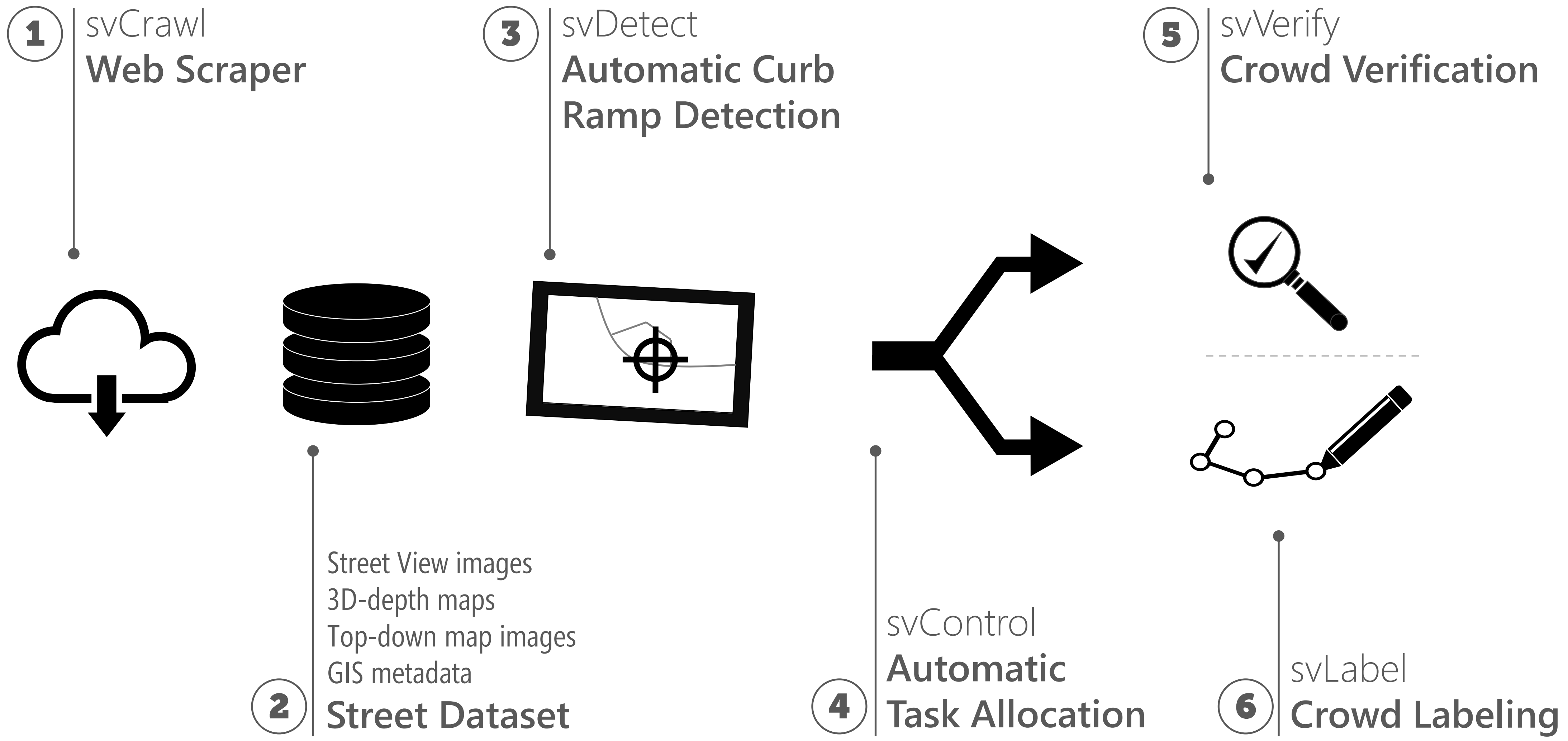
TOHME
遠目 Remote Eye





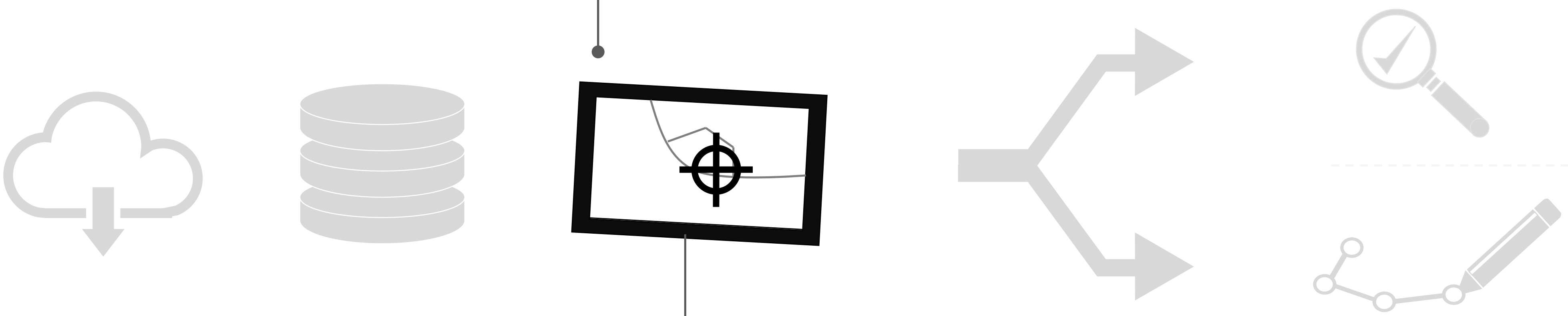
Verifiers **cannot fix false negatives**
(*i.e.*, they cannot add new labels)

TOHME
遠目 Remote Eye



TOHME
遠目 Remote Eye

3 svDetect
Automatic Curb Ramp Detection

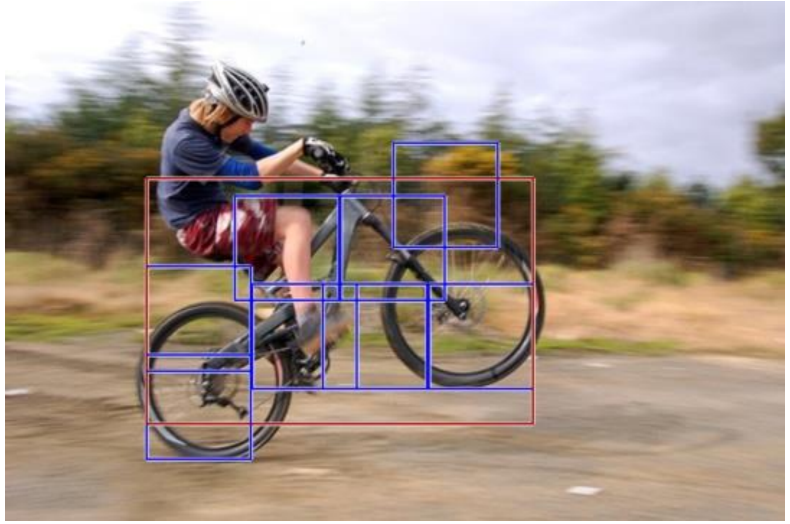


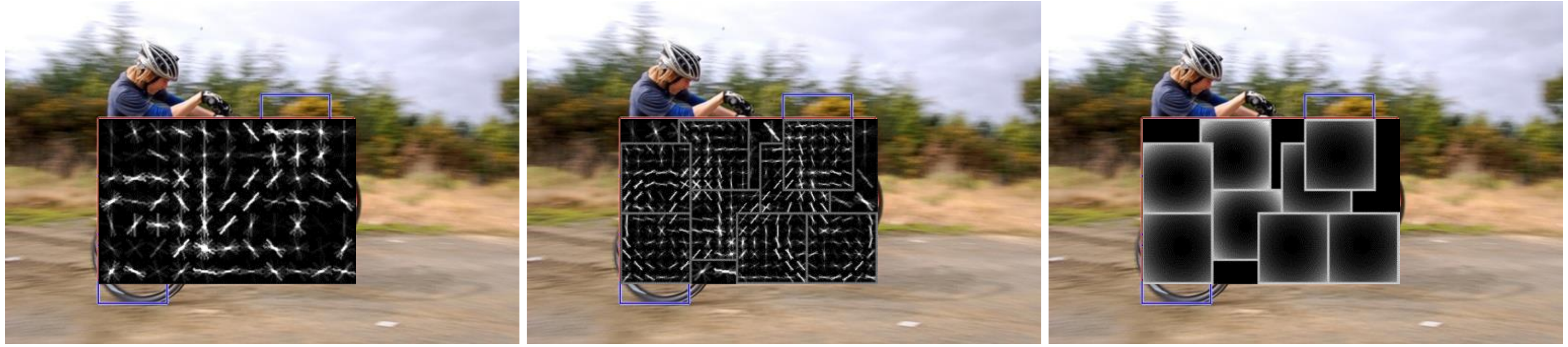
1. Deformable part model (DPM)
2. Post-processing DPM
3. SVM-based classifier

1

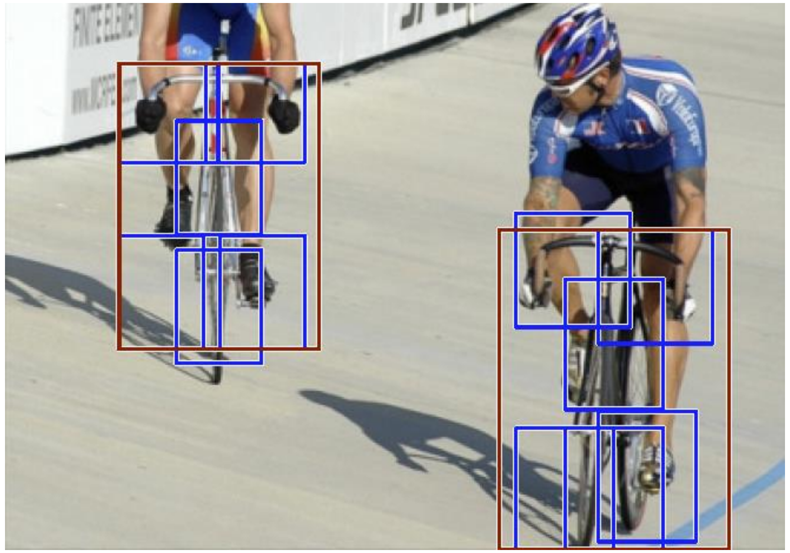
AUTOMATIC CURB RAMP DETECTOR

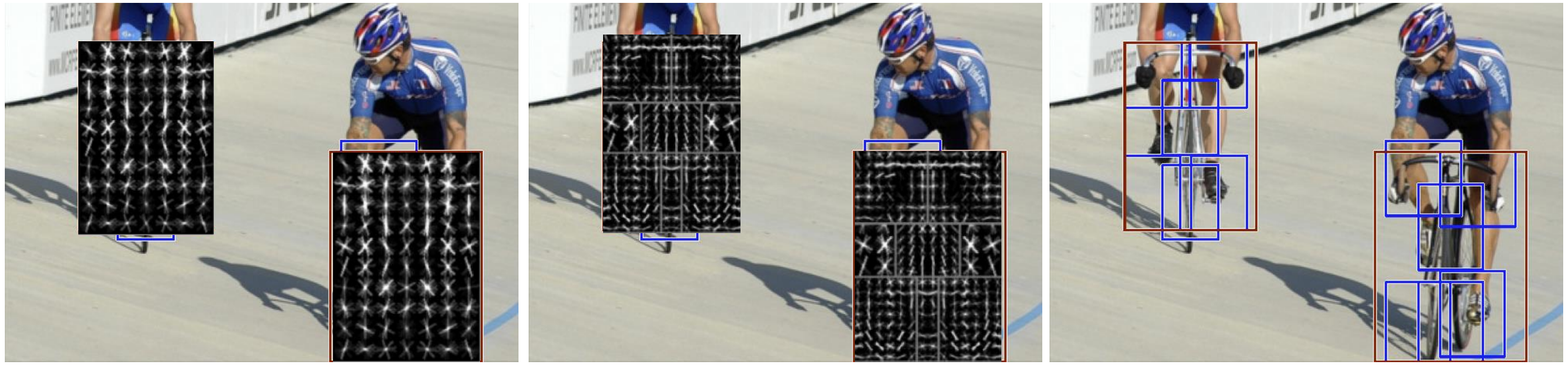
DEFORMABLE PART MODEL





Root filter | Parts filter | Displacement cost





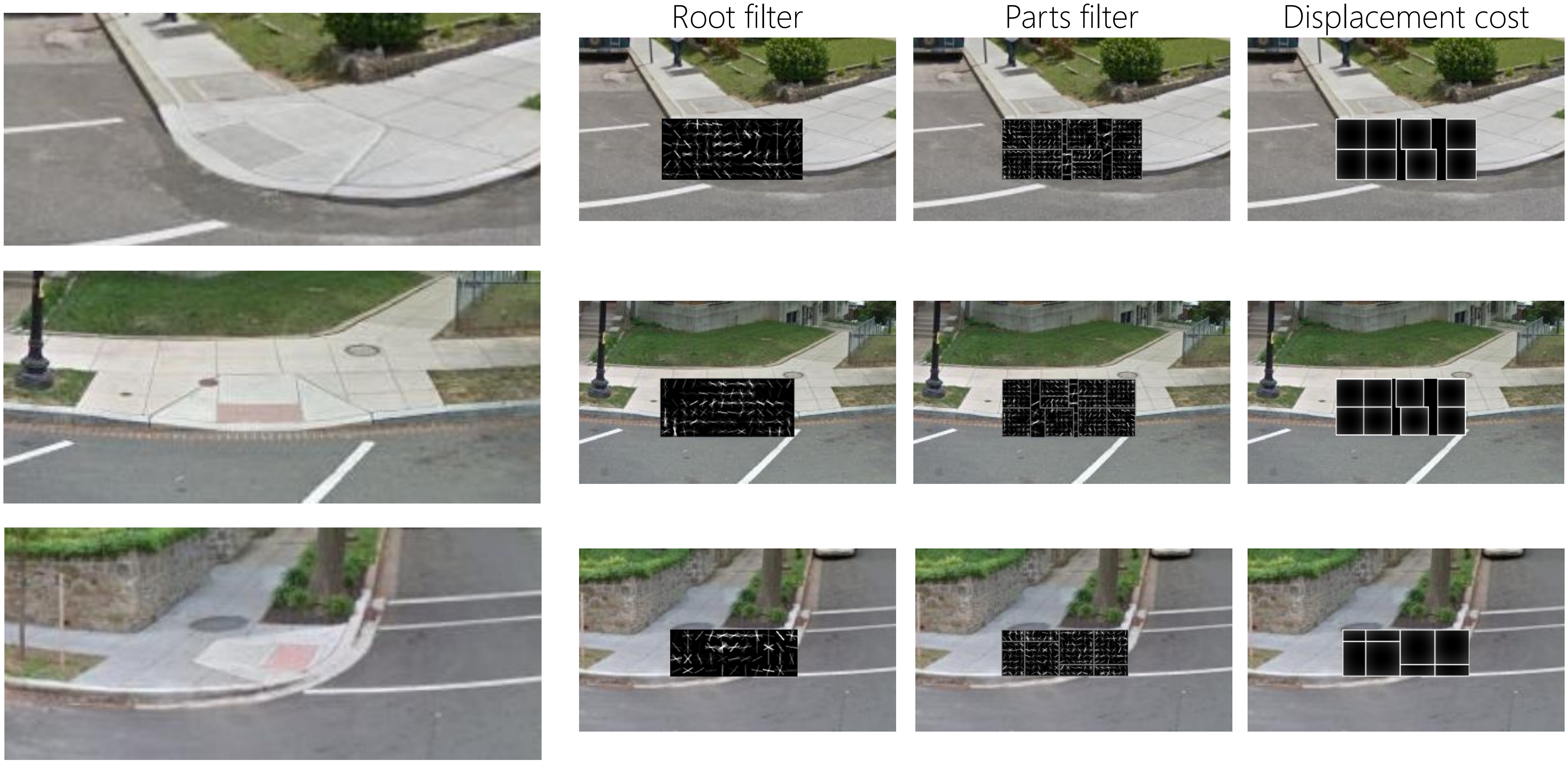
Root filter | Parts filter | Displacement cost

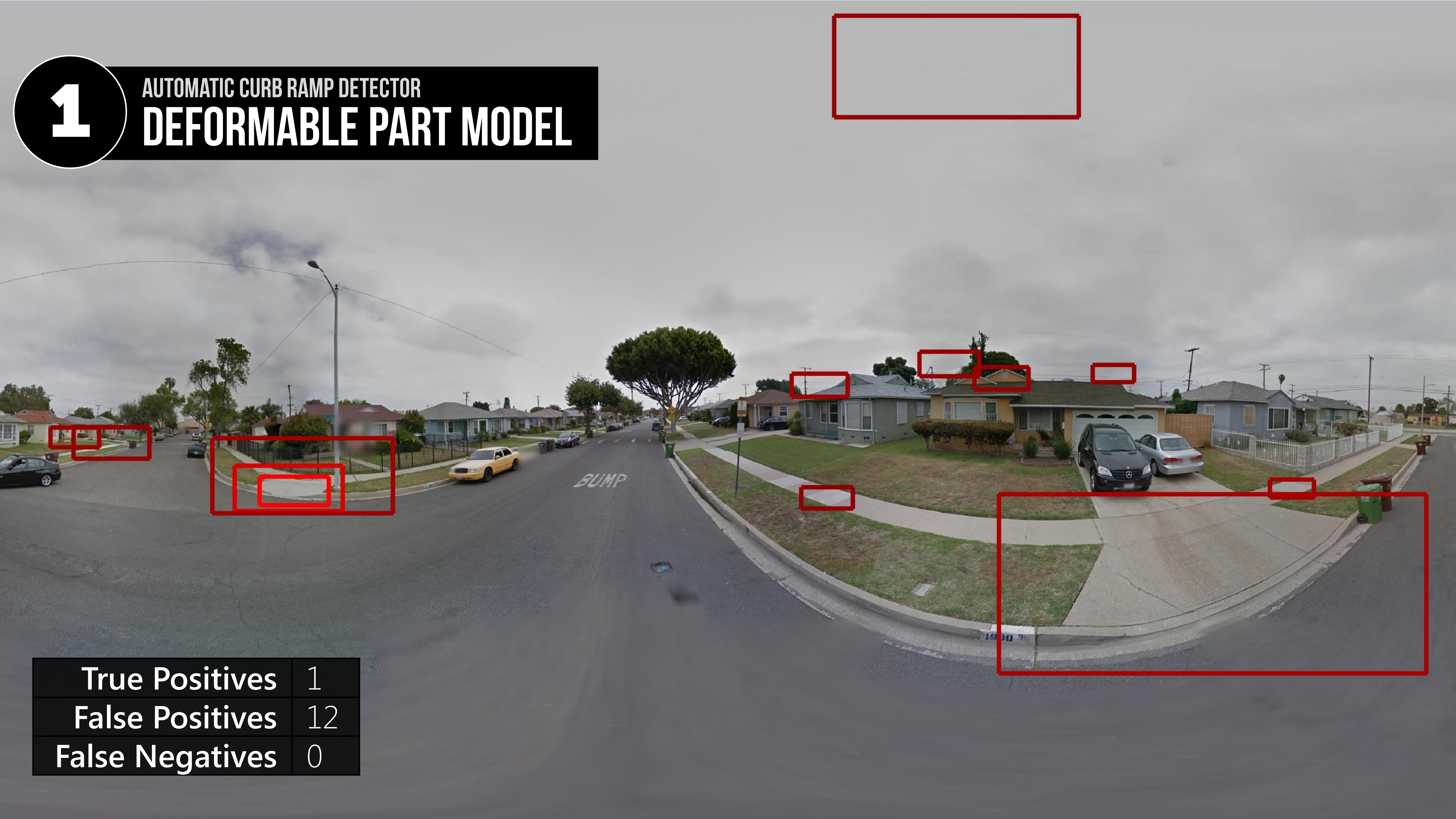
Felzenszwalb *et al.*, CVPR'08, CVPR'10

1

AUTOMATIC CURB RAMP DETECTOR

DEFORMABLE PART MODEL



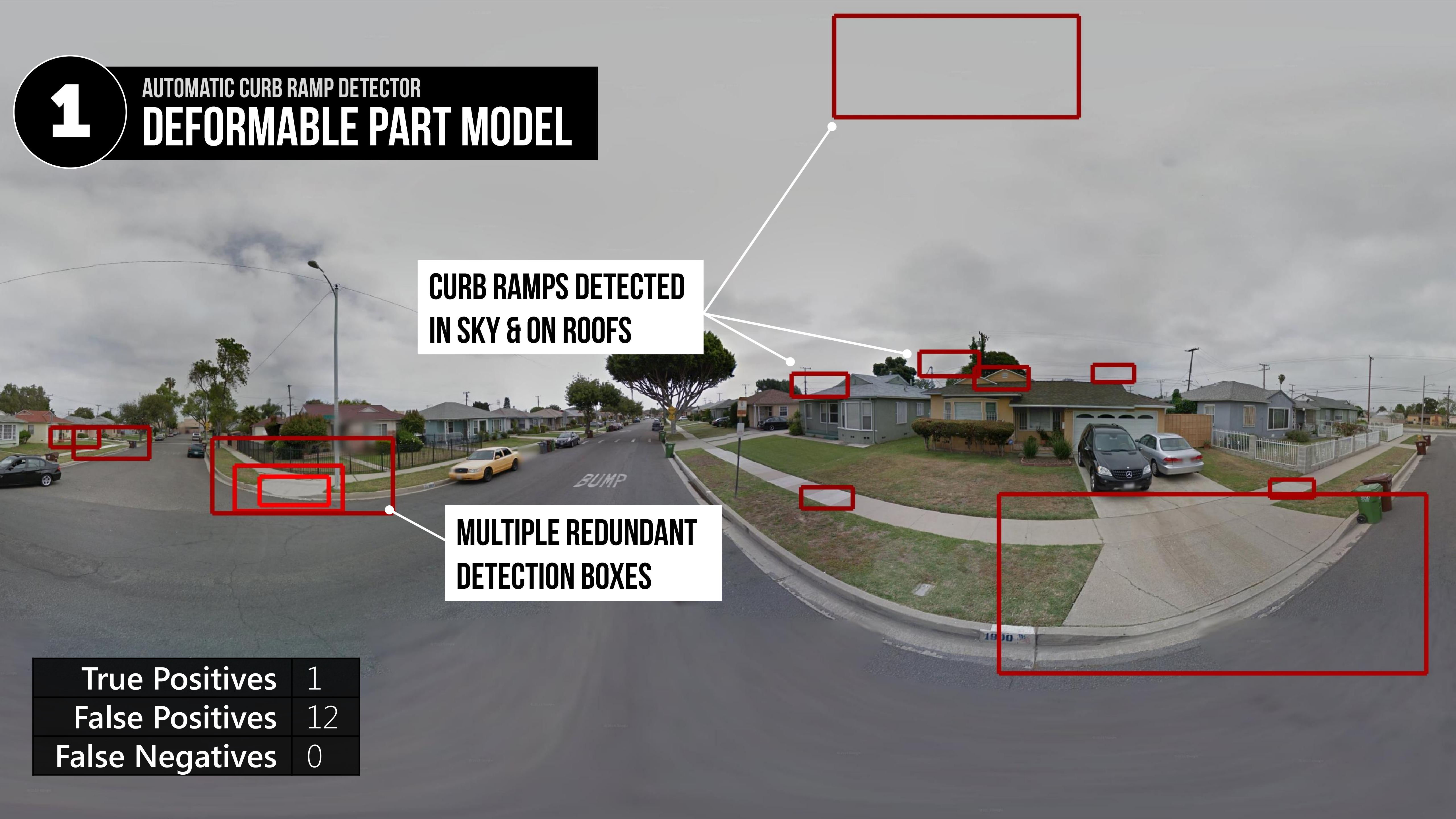


1

AUTOMATIC CURB RAMP DETECTOR

DEFORMABLE PART MODEL

True Positives	1
False Positives	12
False Negatives	0

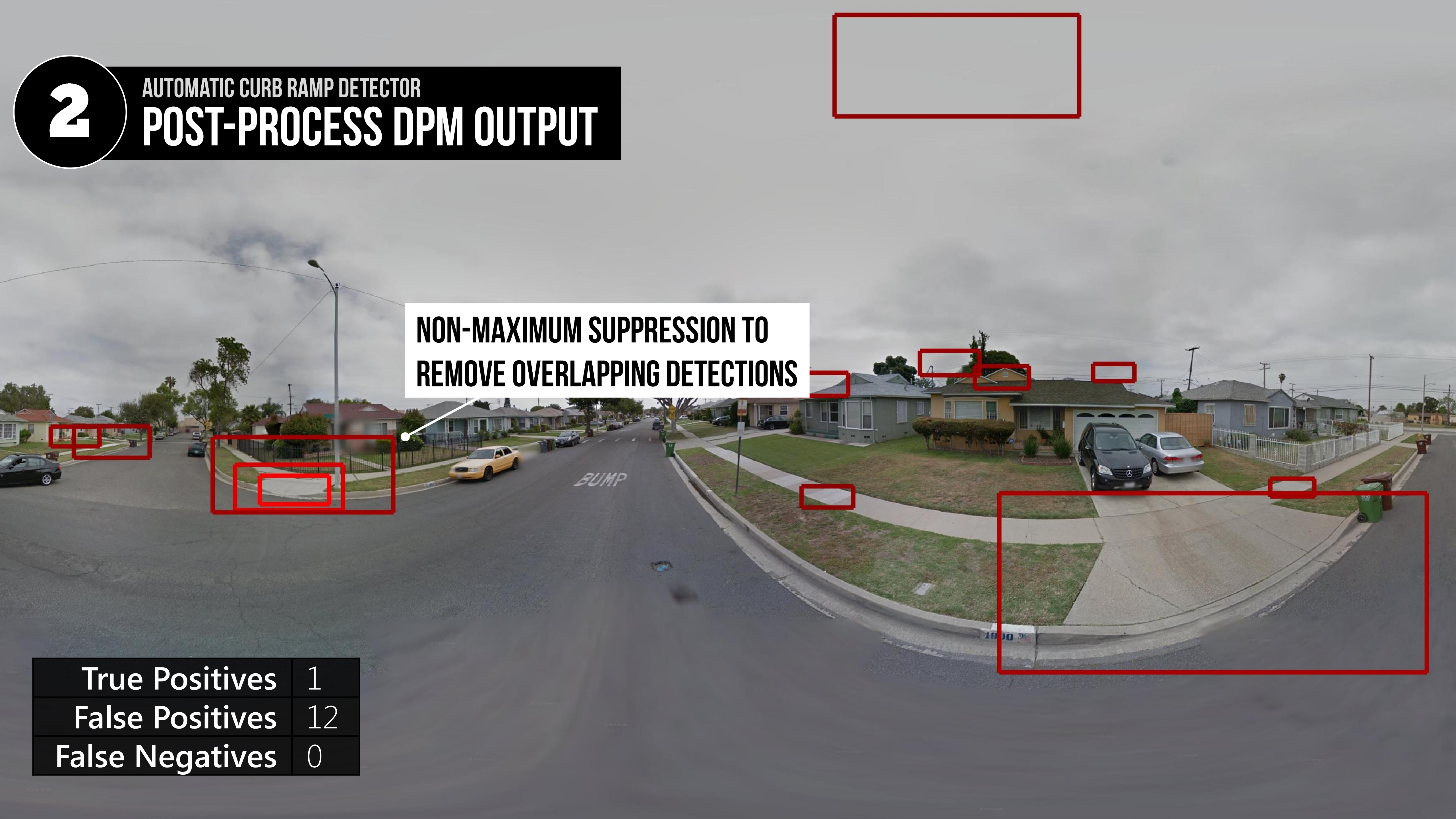

1
AUTOMATIC CURB RAMP DETECTOR
DEFORMABLE PART MODEL
CURB RAMPS DETECTED IN SKY & ON ROOFS
MULTIPLE REDUNDANT DETECTION BOXES
BUMP
True Positives 1
False Positives 12
False Negatives 0


2
AUTOMATIC CURB RAMP DETECTOR
POST-PROCESS DPM OUTPUT
3D-POINT CLOUD TO REMOVE
CURB RAMPS ABOVE GROUND
BUMP

2

AUTOMATIC CURB RAMP DETECTOR

POST-PROCESS DPM OUTPUT



True Positives	1
False Positives	12
False Negatives	0

2

AUTOMATIC CURB RAMP DETECTOR

POST-PROCESS DPM OUTPUT

True Positives	1
False Positives	5
False Negatives	0

3

AUTOMATIC CURB RAMP DETECTOR

SVM-BASED REFINEMENT

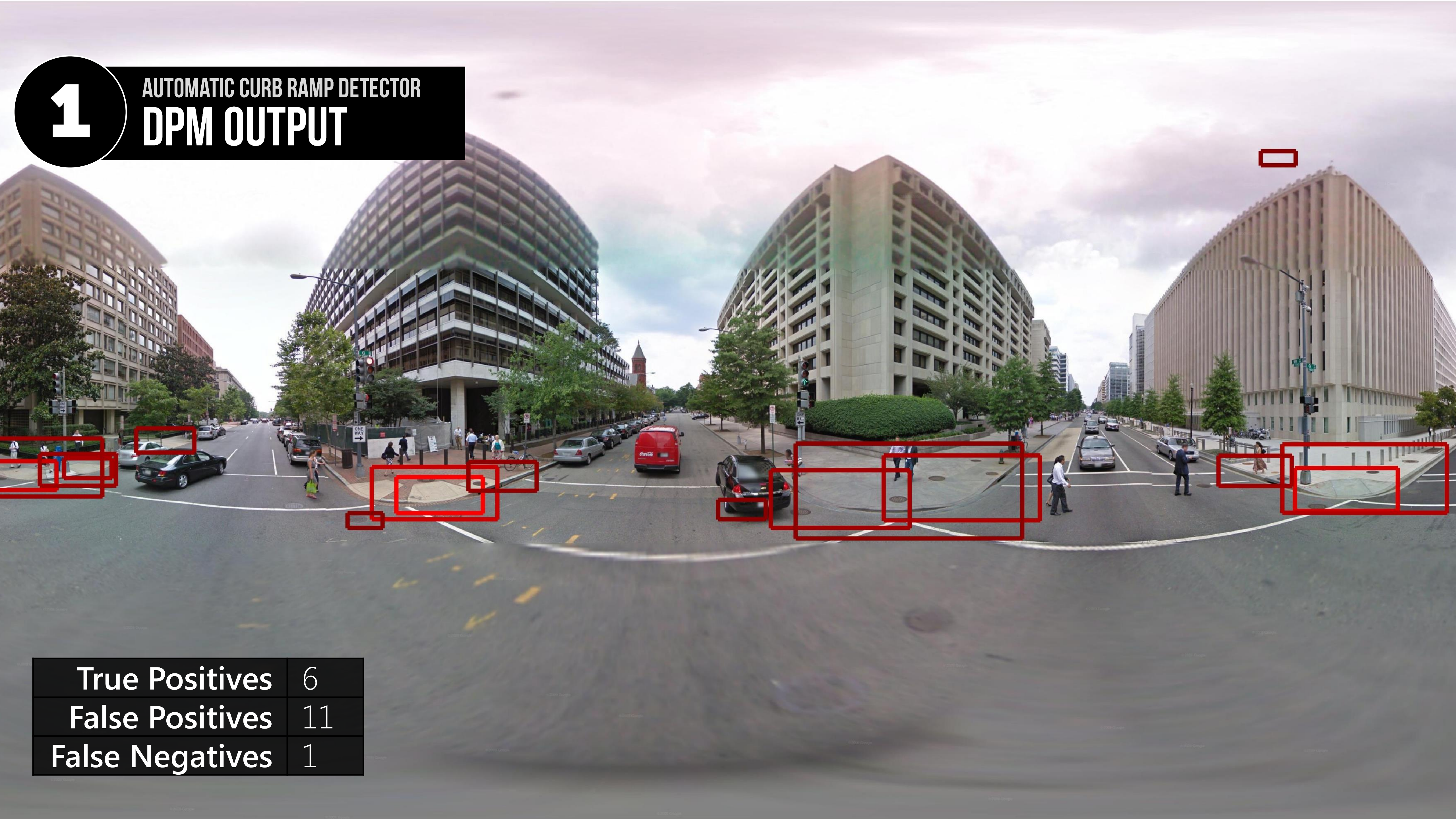
True Positives	1
False Positives	5
False Negatives	0

3

AUTOMATIC CURB RAMP DETECTOR

FINAL OUTPUT

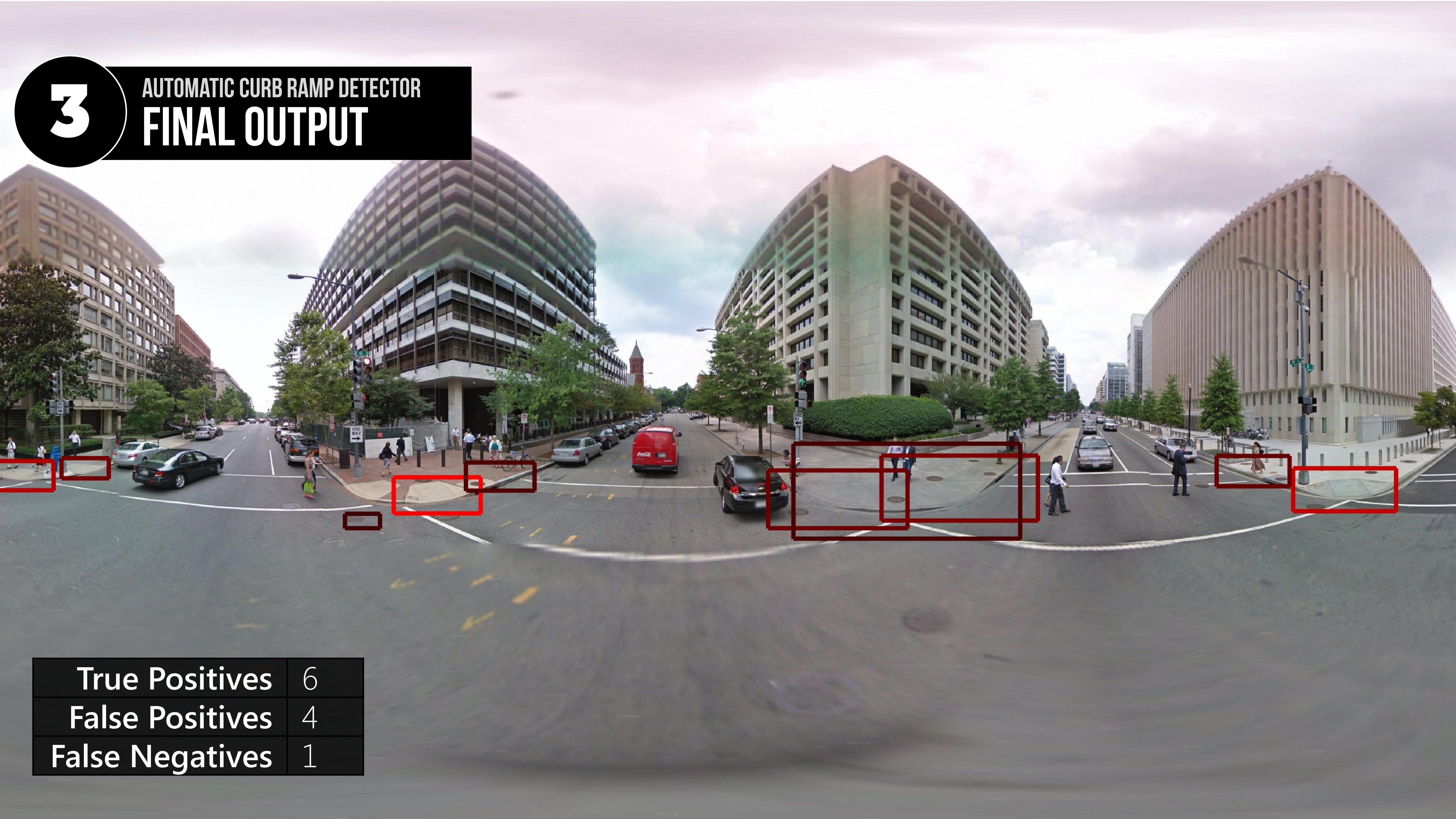
True Positives	1
False Positives	3
False Negatives	0


1
AUTOMATIC CURB RAMP DETECTOR
DPM OUTPUT
True Positives 6
False Positives 11
False Negatives 1

3

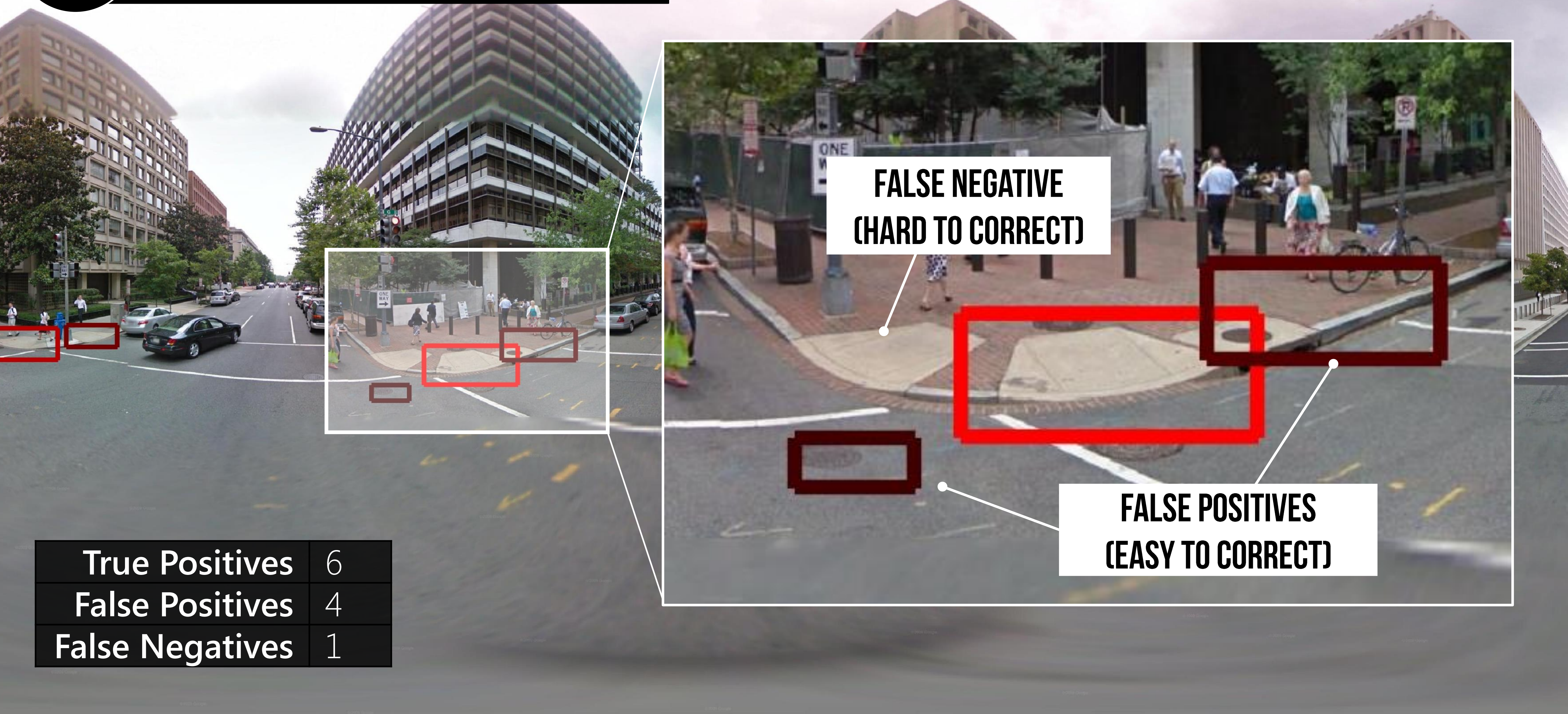
AUTOMATIC CURB RAMP DETECTOR

FINAL OUTPUT



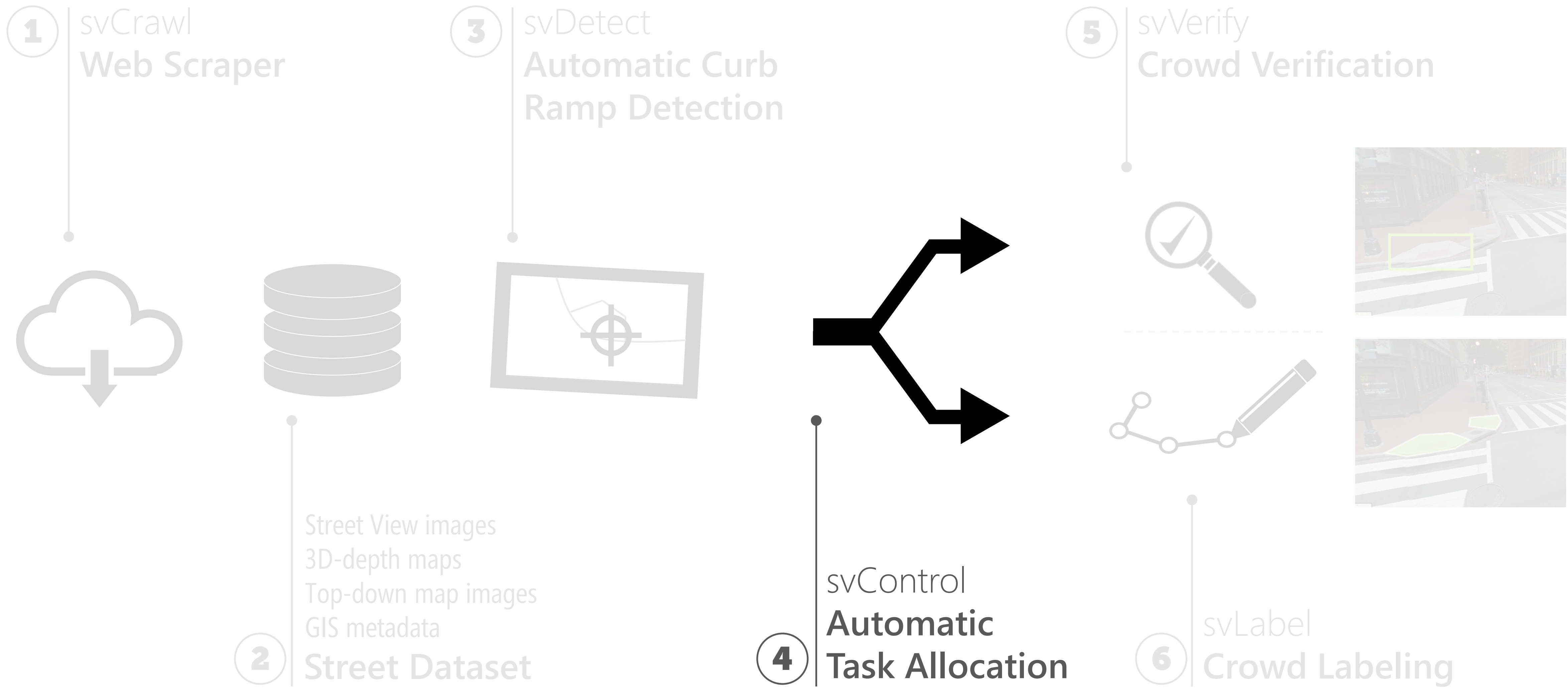
True Positives	6
False Positives	4
False Negatives	1

3 AUTOMATIC CURB RAMP DETECTOR
FINAL OUTPUT



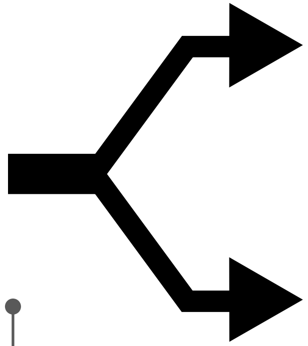
True Positives	6
False Positives	4
False Negatives	1

TOHME
遠目 Remote Eye



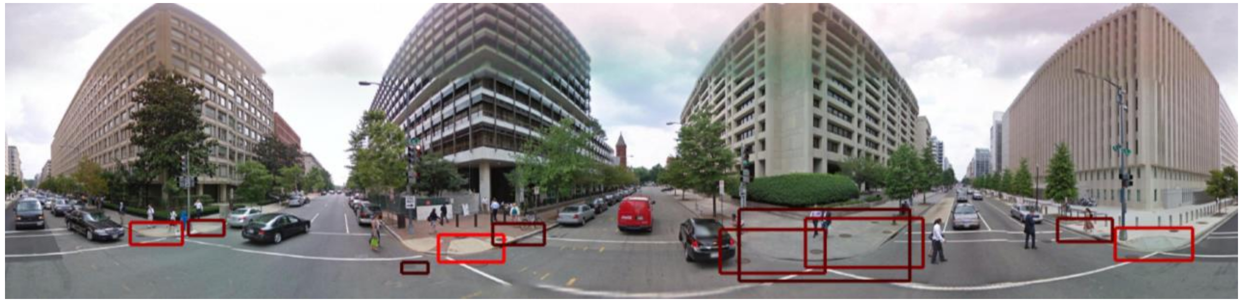
SVM TRAINED WITH 23 INPUT FEATURES

Binary classifier trained to predict occurrence of false negatives from svDetect stage



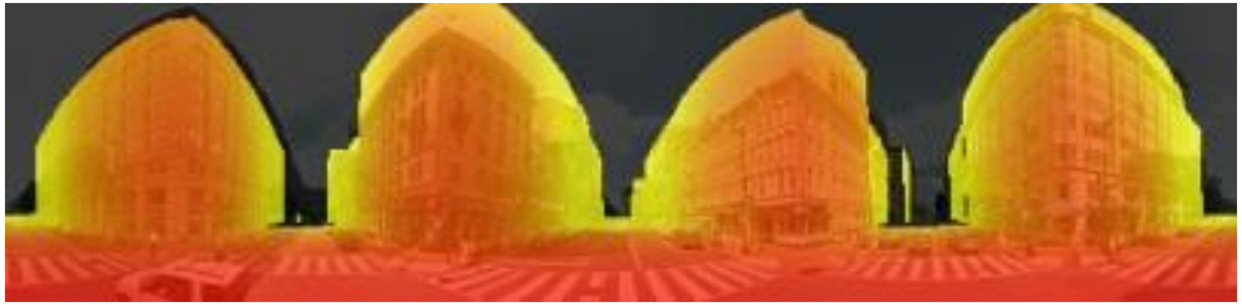
4 svControl **Automatic Task Allocation**

Curb Ramp Detector Output (16 Features)



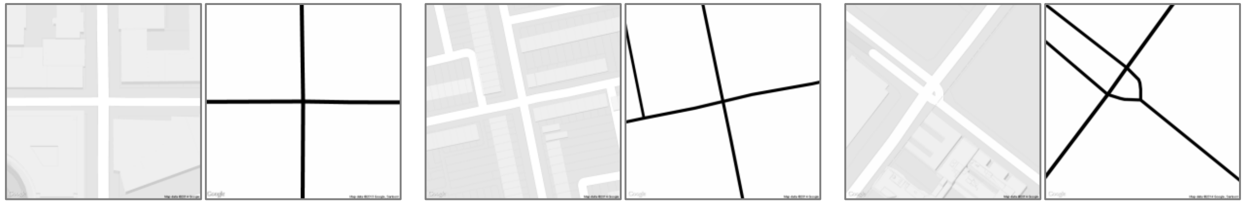
Raw # of bounding boxes
Descriptive stats of confidence scores
Descriptive stats of XY-coordinates

3D-Point Cloud Data (5 Features)



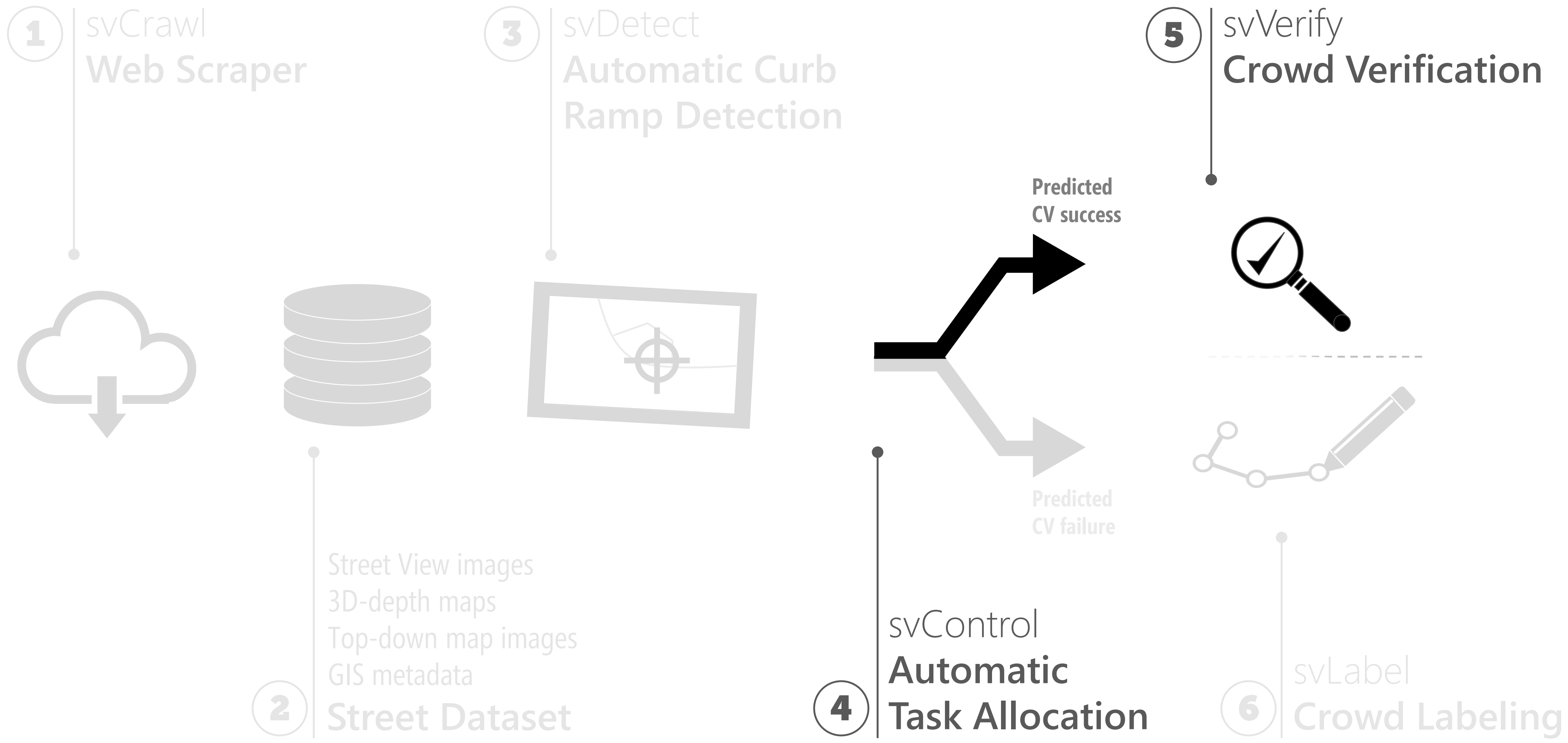
Descriptive stats of depth information (*e.g.,* average, median, variance) of pixel depth

Intersection Complexity (2 Features)



Cardinality (# of connected streets)
Amount of road

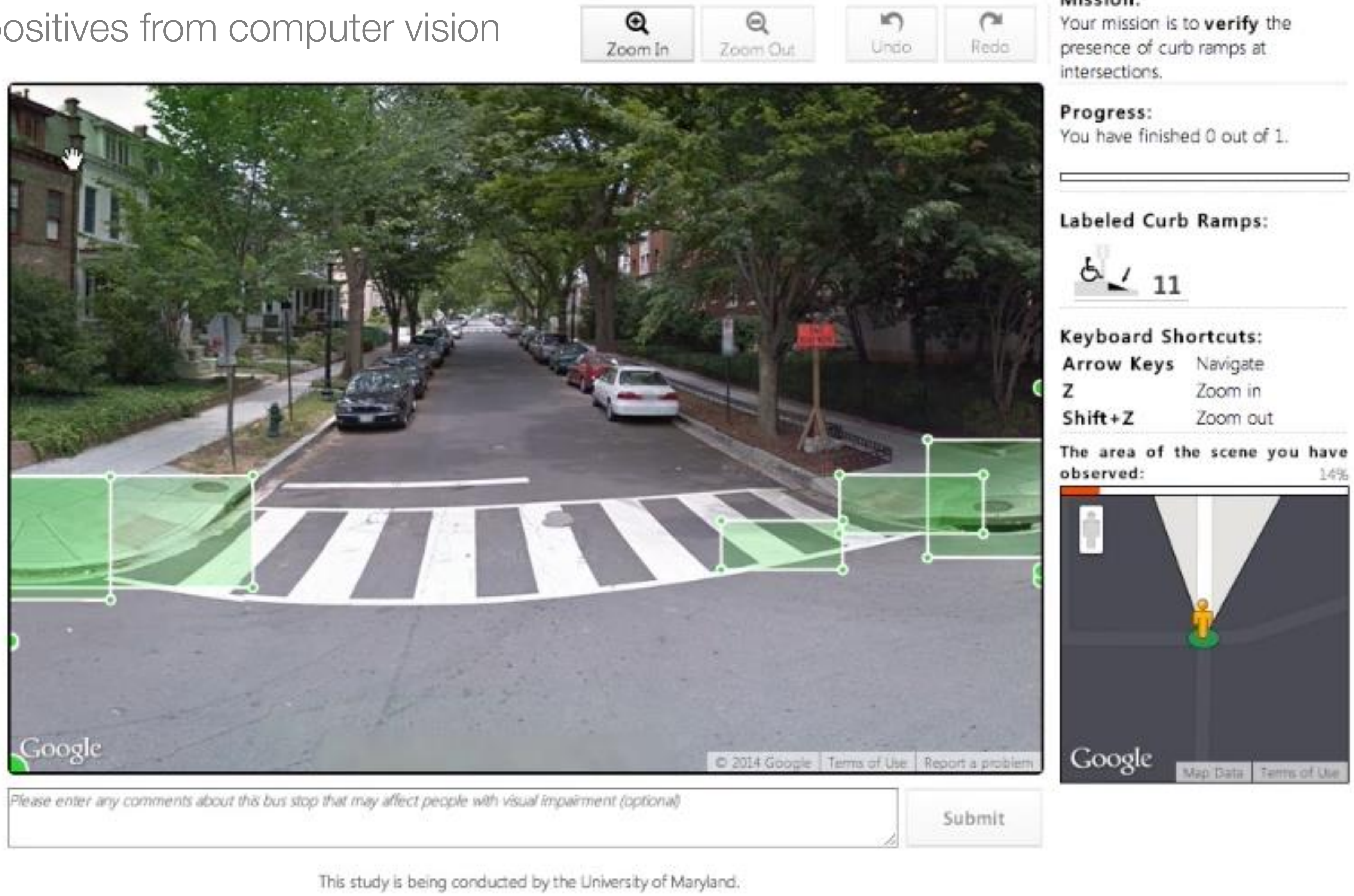
TOHME
遠目 Remote Eye



CROWD INTERFACES

VERIFICATION TOOL

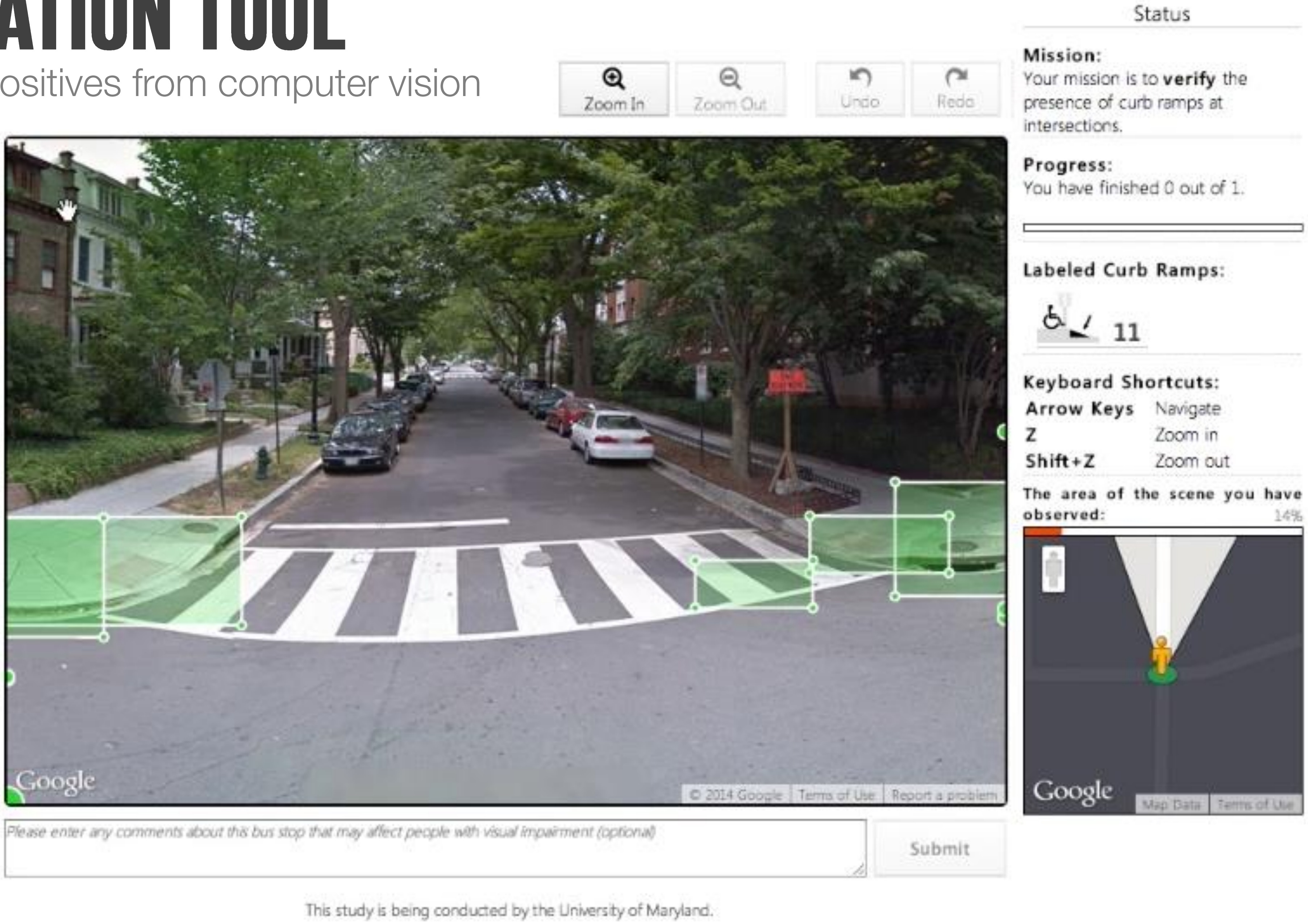
Correct false positives from computer vision



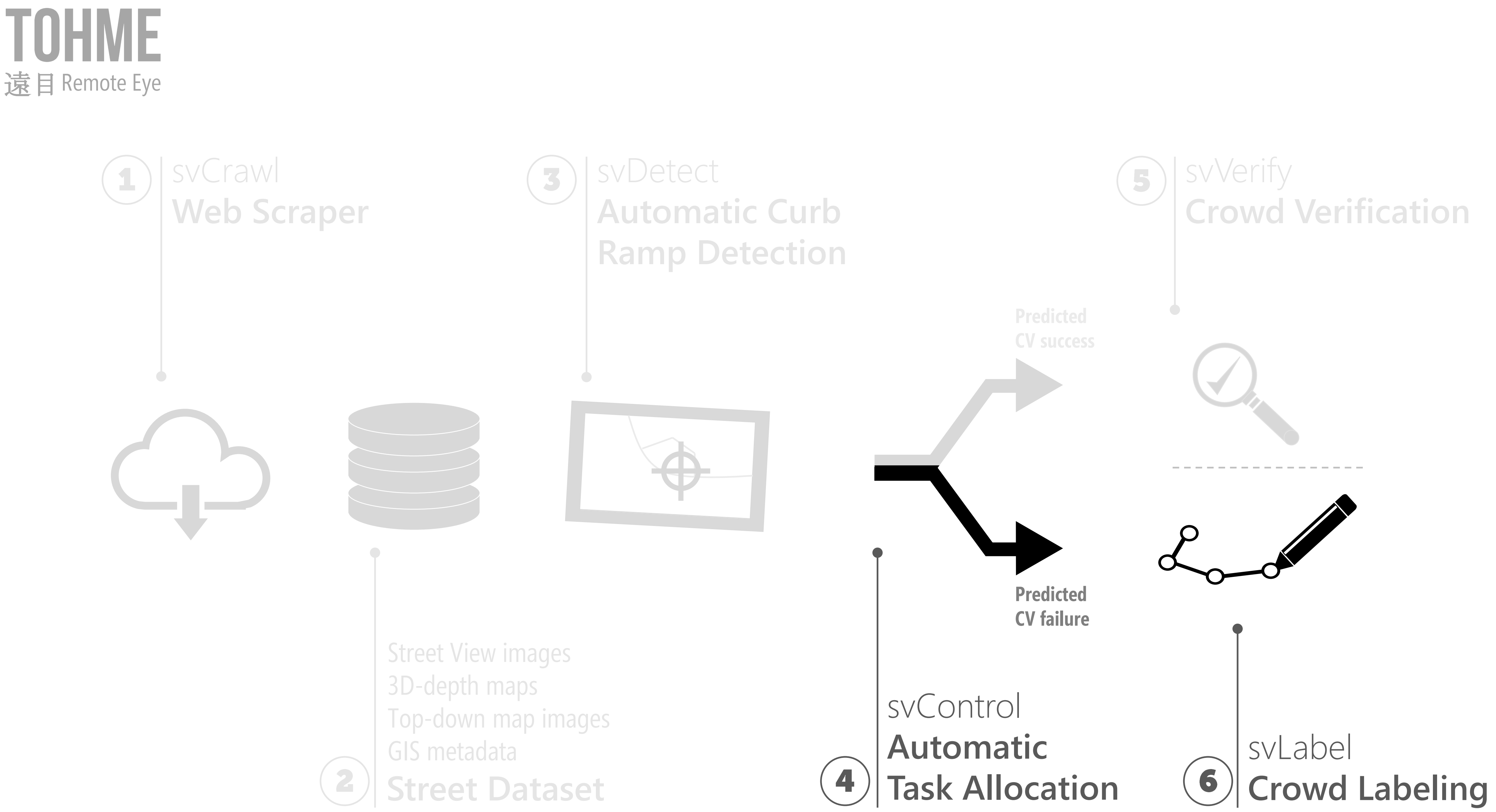
CROWD INTERFACES

VERIFICATION TOOL

Correct false positives from computer vision

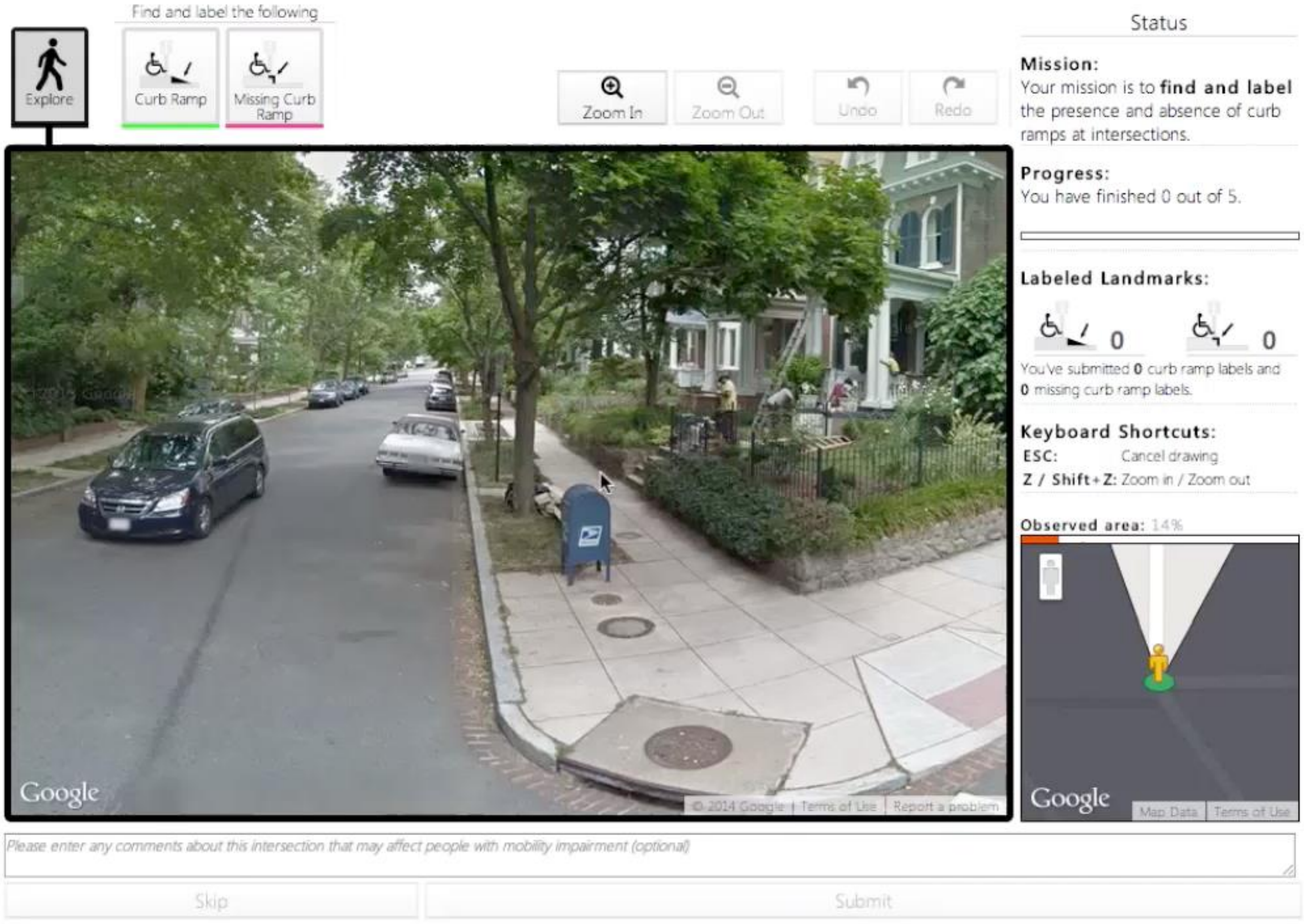


Playback Speed: **2x**

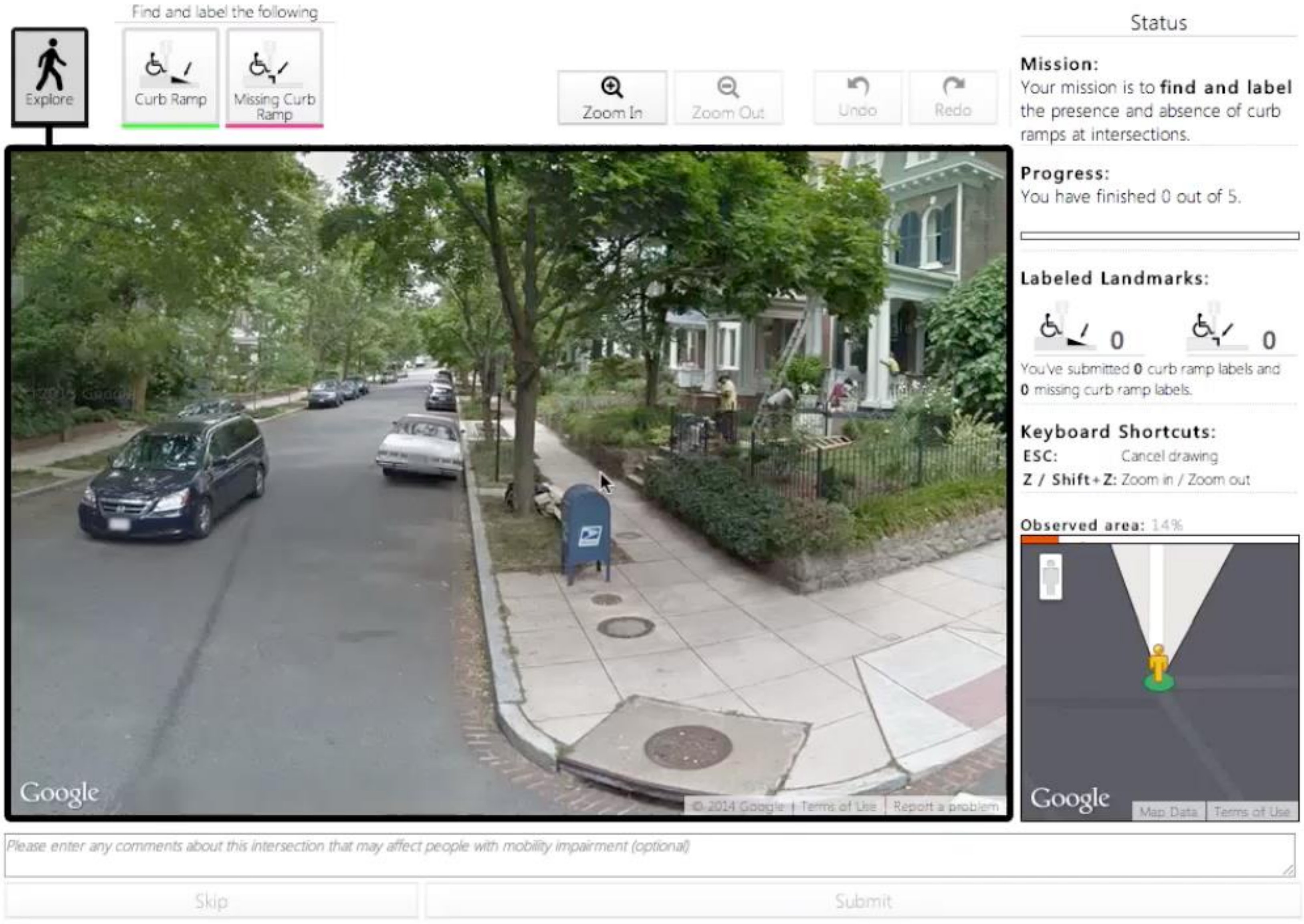

TOHME
遠目 Remote Eye
1 svCrawl
Web Scraper
3 svDetect
Automatic Curb
Ramp Detection
5 svVerify
Crowd Verification
Predicted
CV success
Predicted
CV failure
Street View images
3D-depth maps
Top-down map images
GIS metadata
2 Street Dataset
svControl
4 Automatic
Task Allocation
svLabel
6 Crowd Labeling

CROWD INTERFACES

LABELING TOOL



LABELING TOOL



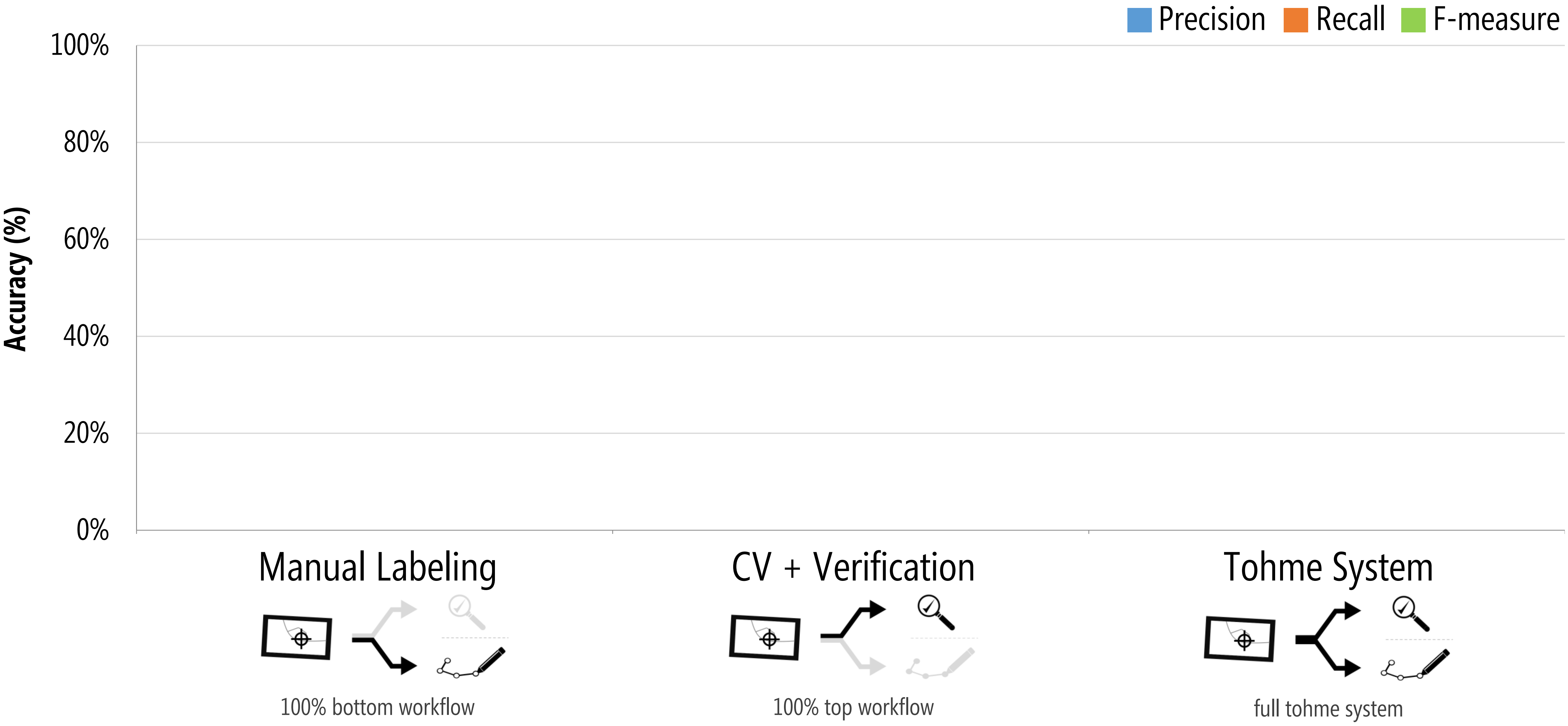
Playback Speed: **2x**

STUDY METHOD

1. Generate ground truth labels
2. Train computer vision & task controller
3. Deploy Tohme to Mechanical Turk
4. Compare Tohme to baseline

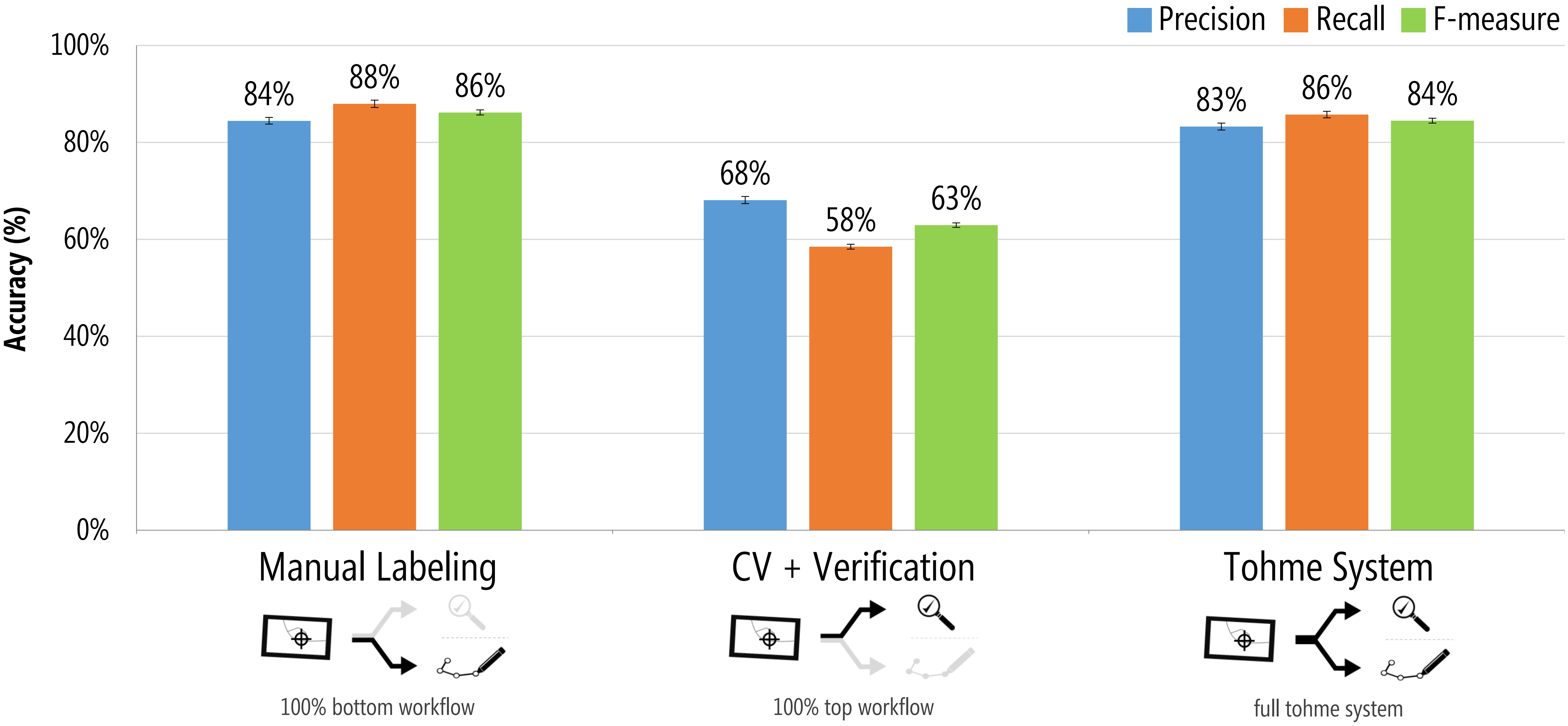
TOHME EVALUATION

OVERALL RESULTS



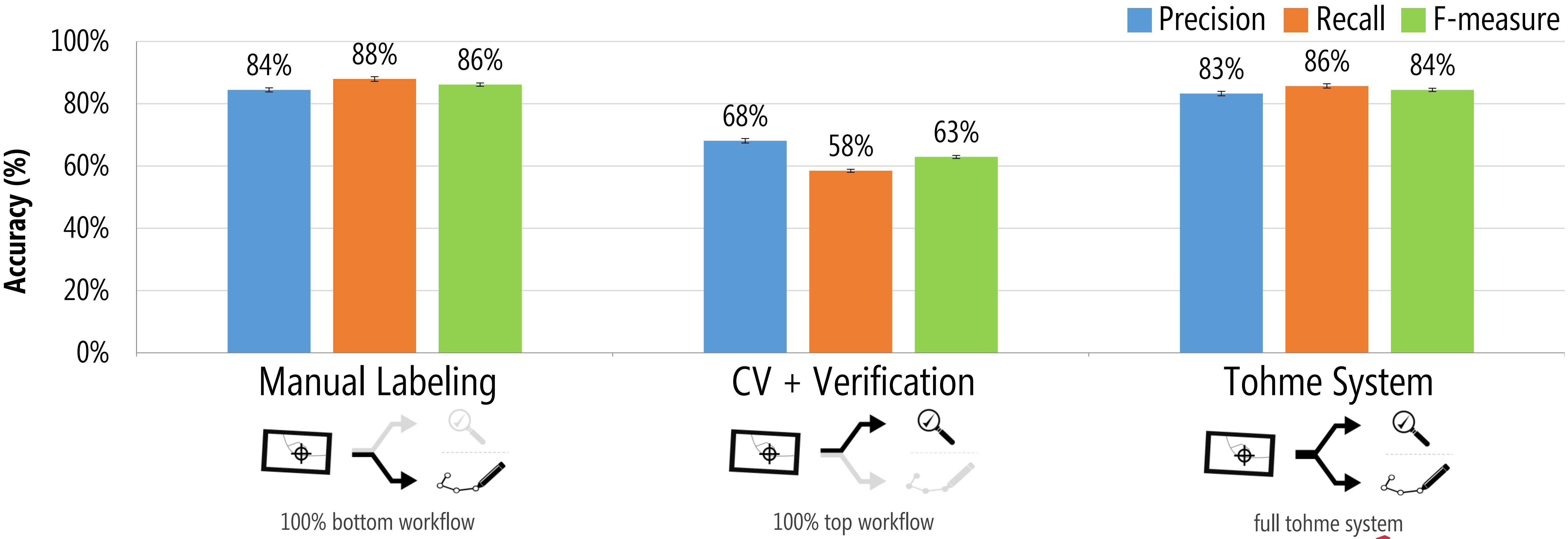
TOHME EVALUATION

OVERALL RESULTS



TOHME EVALUATION

OVERALL RESULTS



94s
PER SCENE

42s
PER SCENE

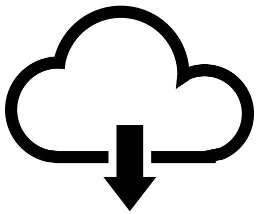
14% faster

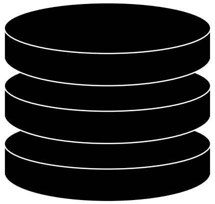
81s
PER SCENE

TOHME EVALUATION

TASK CONTROLLER PERFORMANCE

1 svCrawl
Web Scraper

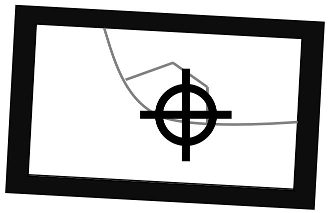


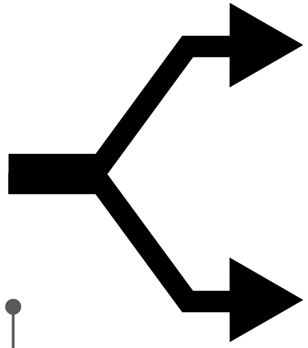


Street View images
3D-depth maps
Top-down map images
GIS metadata

2 **Street Dataset**

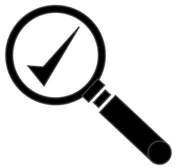
3 svDetect
Automatic Curb Ramp Detection



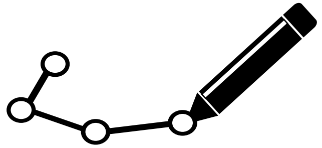


4 svControl
Automatic Task Allocation

5 svVerify
Crowd Verification



80%
SCENES CORRECTLY ROUTED



50%
SCENES CORRECTLY ROUTED

6 svLabel
Crowd Labeling

TOHME EVALUATION

SIMULATED PERFECT TASK CONTROLLER

5 svVerify
Crowd Verification

Simulated perfect task controller

100%
SCENES CORRECTLY ROUTED

100%
SCENES CORRECTLY ROUTED

OVERALL SPEEDUP INCREASES OVER MANUAL BASELINE

14% SPEEDUP → **27%** SPEEDUP

4 svControl
Automatic
Task Allocation

6 svLabel
Crowd Labeling

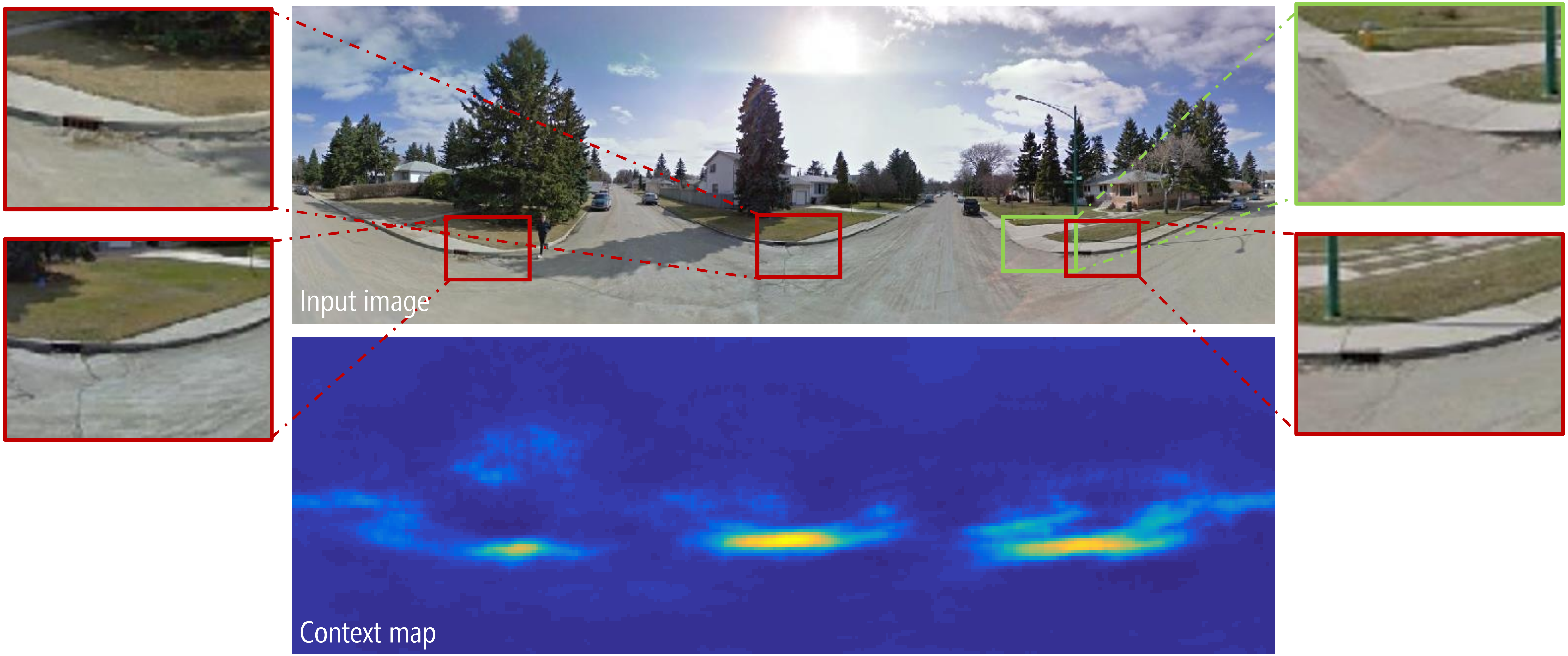
CURRENT & FUTURE WORK

1. Improving detection algorithms
2. Project Sidewalk
3. New workflows & interfaces
4. Developing new assistive technologies

CURRENT & FUTURE WORK

APPLYING CONVOLUTIONAL NEURAL NETWORKS

Recently accepted to CVPR'17



PROJECT

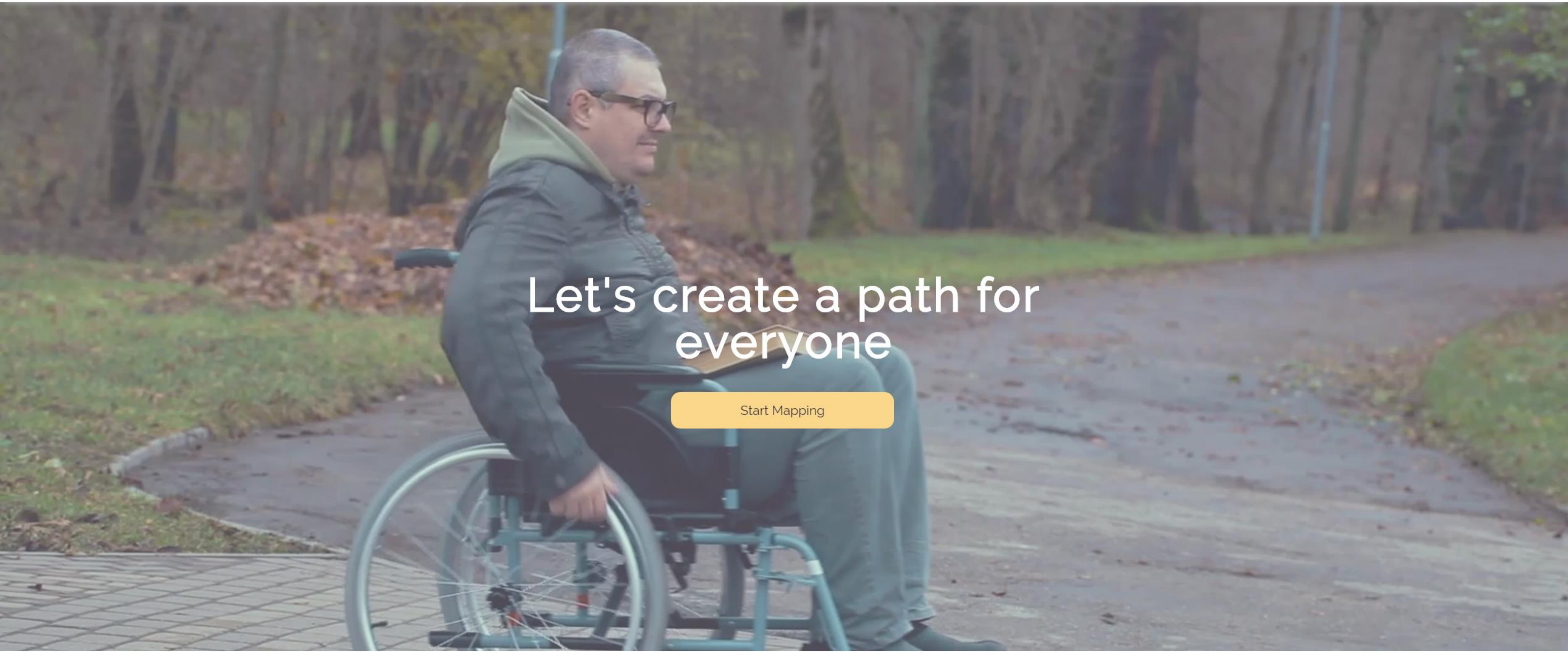
SIDEWALK

HTTP://PROJECTSIDEWALK.IO

PROJECT SIDEWALK

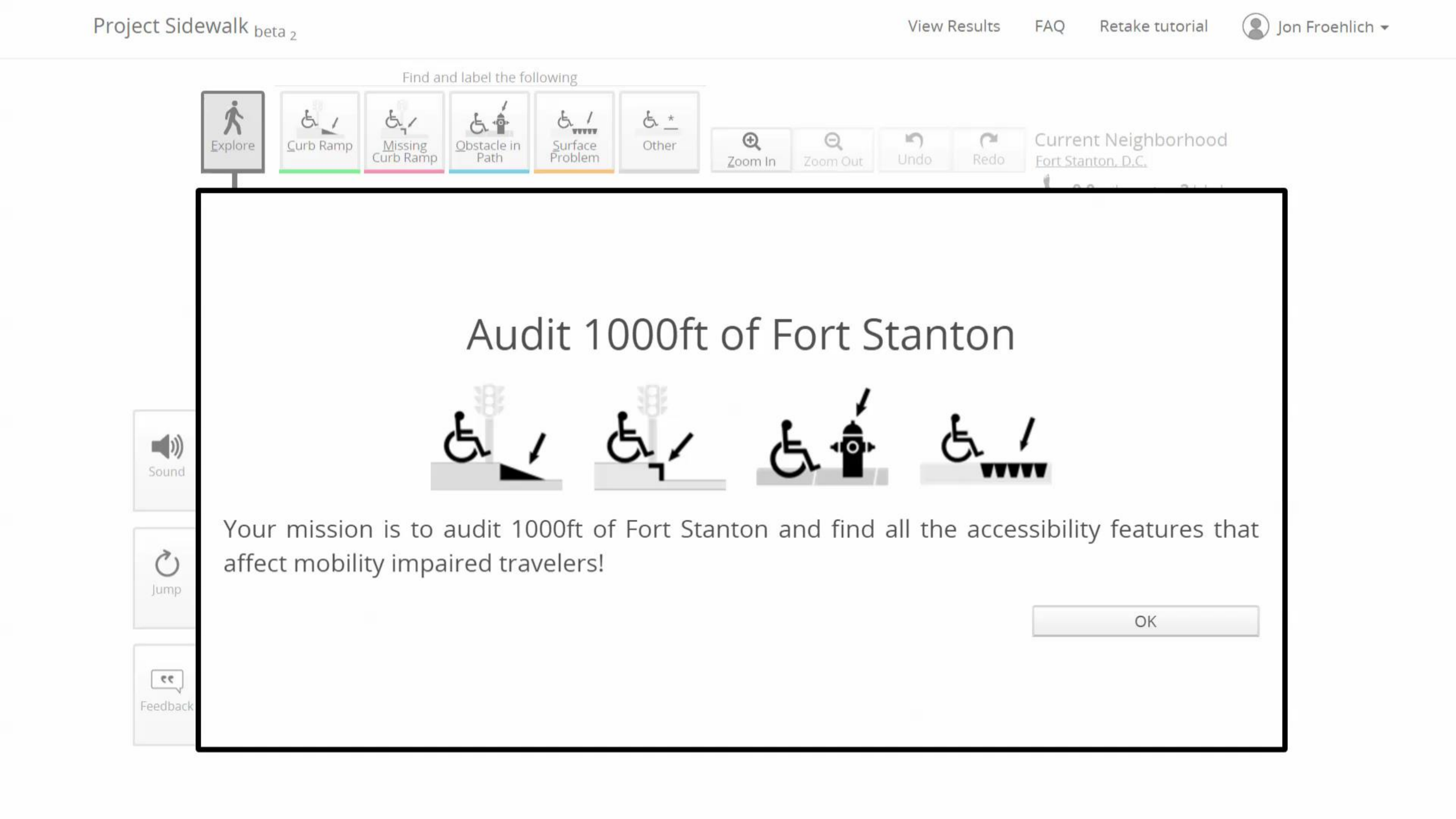
Start Mapping

Jon Froehlich



How you can help

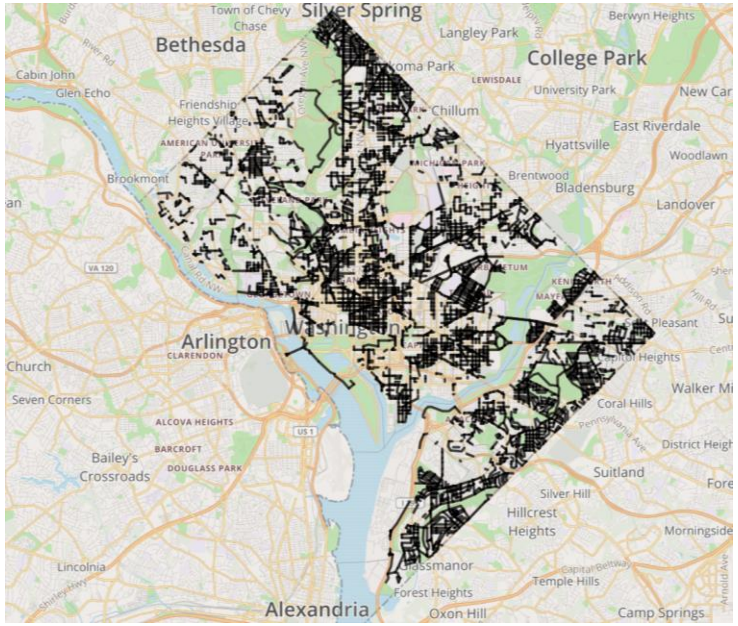
Virtually explore city streets to find and label accessibility


Project Sidewalk beta 2
View Results
FAQ
Retake tutorial
Jon Froehlich
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 Stanton, D.C.
Sound
Jump
Feedback
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

PROJECT SIDEWALK CONTRIBUTIONS

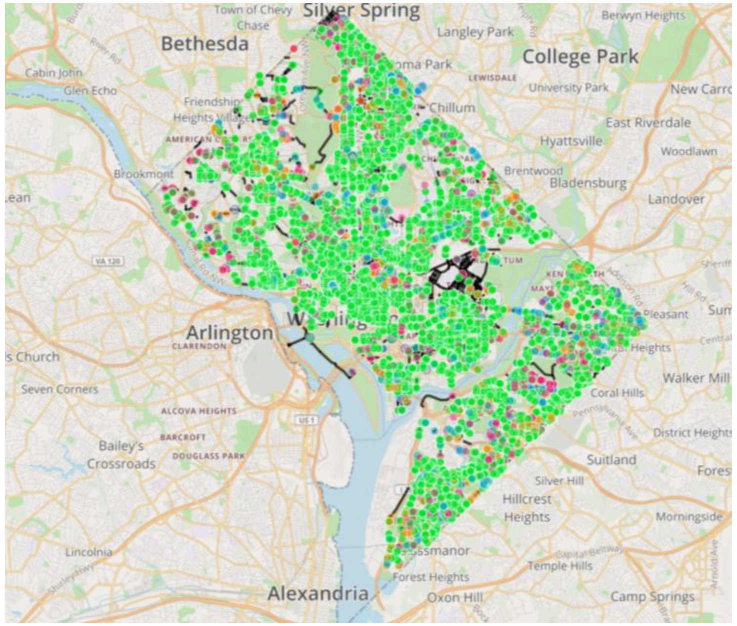
500

USERS



470

MILES



66,000

LABELS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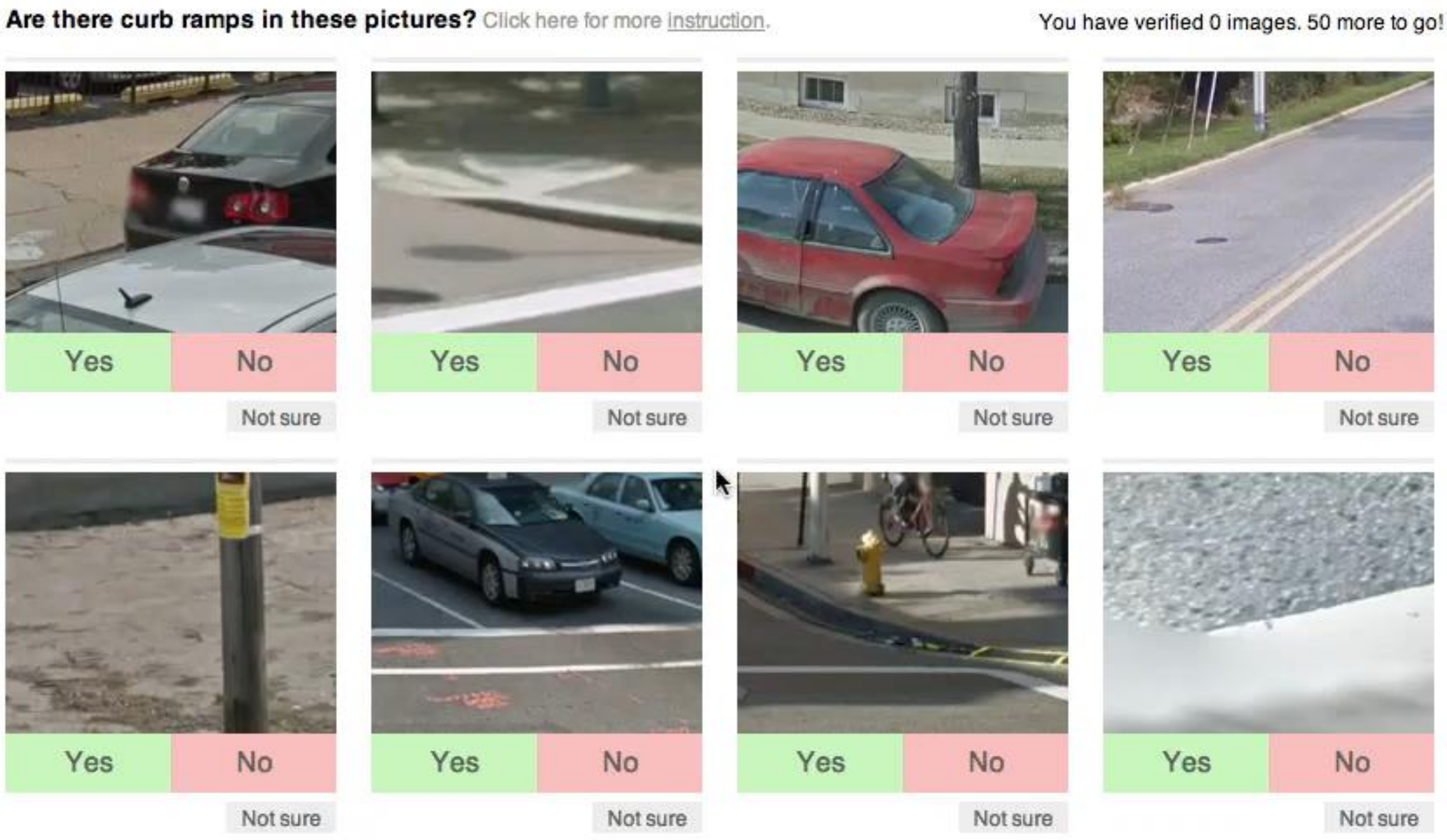
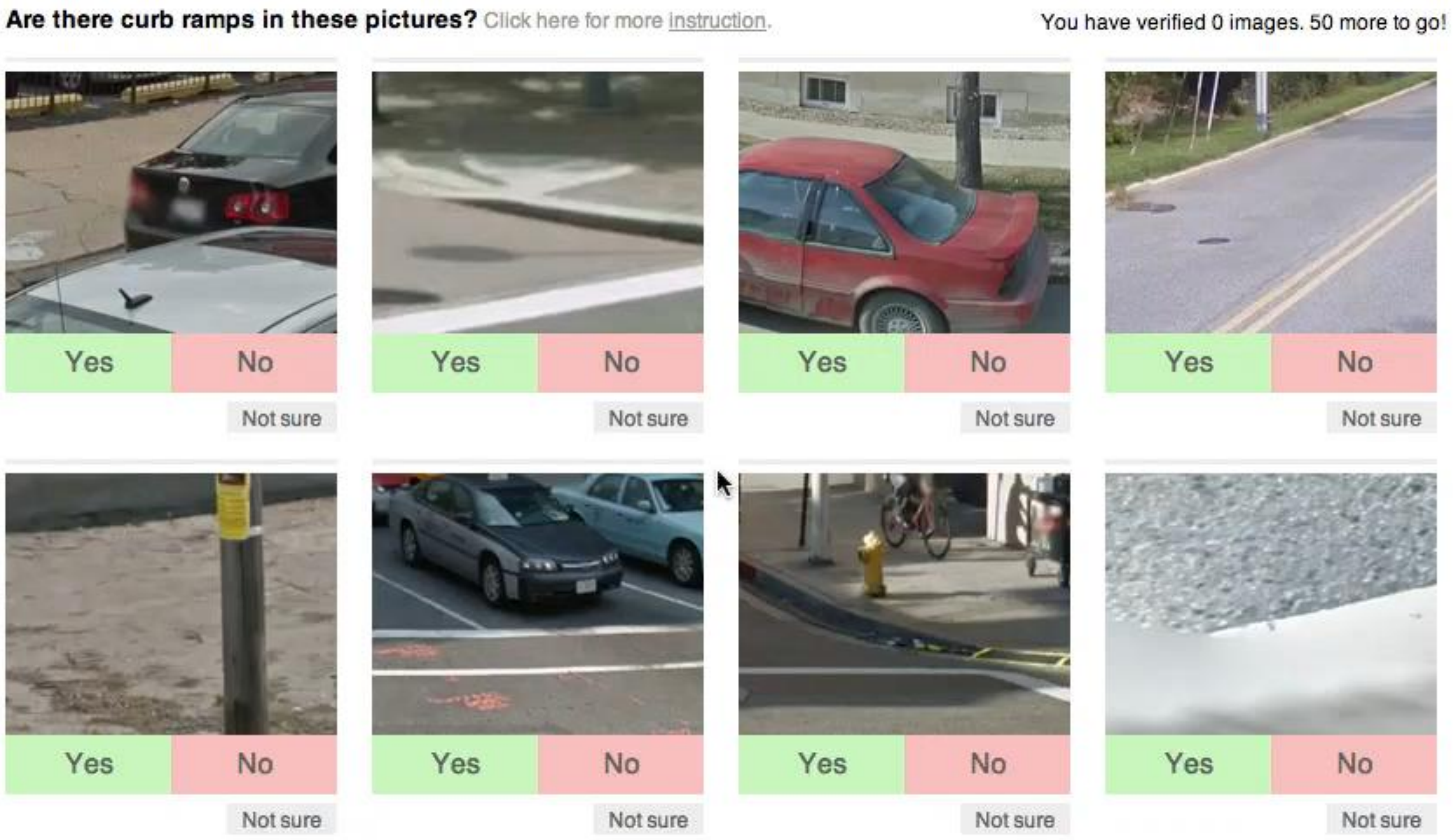
18951.jpg
18942.jpg
18944.jpg

CURRENT & FUTURE WORK

NEW HYBRID WORKFLOWS & INTERFACES



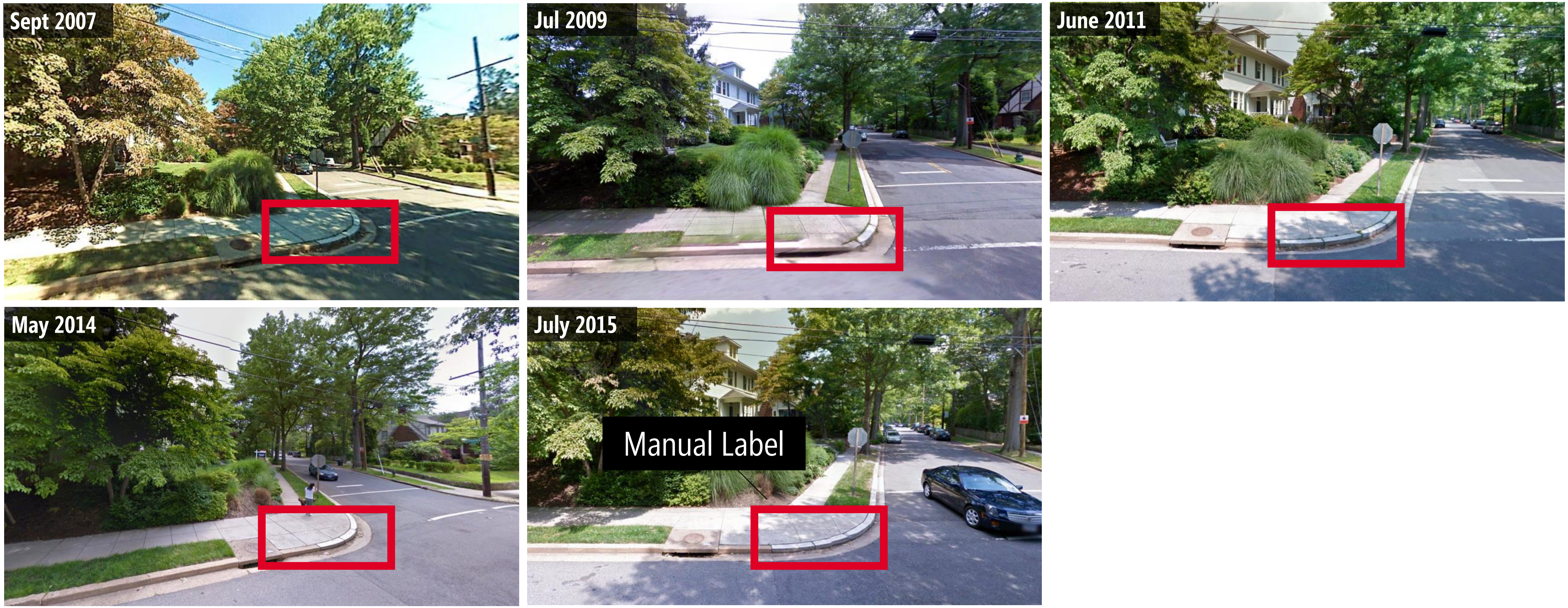
NEW HYBRID WORKFLOWS & INTERFACES




2906 34th St NW
Washington, District of Columbia
Street View - Sep 2007
34th St NW
Garfield St NW
Back to Map
Google
Image capture: Sep 2007
© 2014 Google
Terms
Privacy
Report a problem

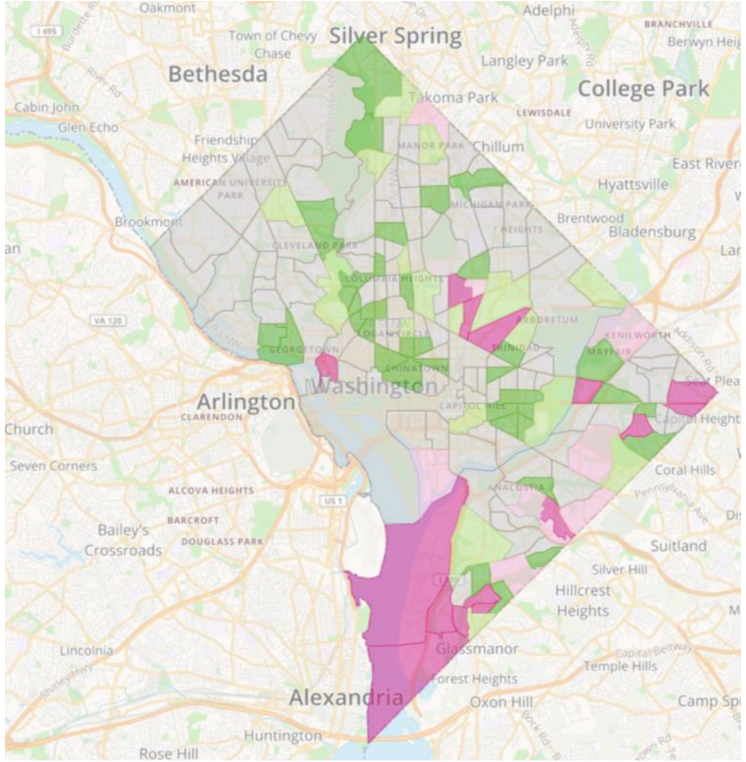
FUTURE WORK

TRACKING ACCESSIBILITY INFRASTRUCTURE OVER TIME



PROJECT SIDEWALK

NOVEL ASSISTIVE TECHNOLOGY APPLICATIONS



New models & viz of city accessibility

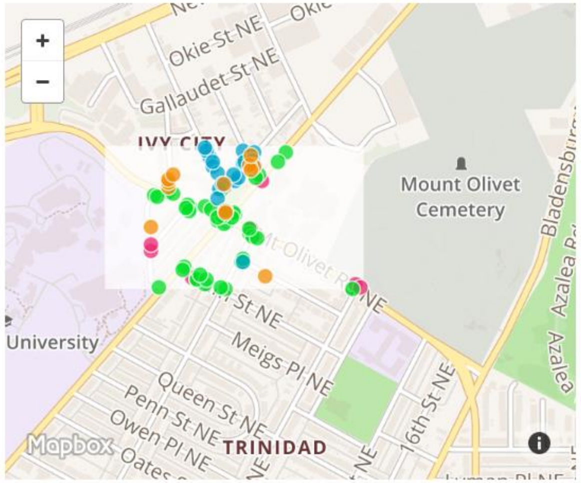
Smart routing for people with impairments

DC

vs

NYC

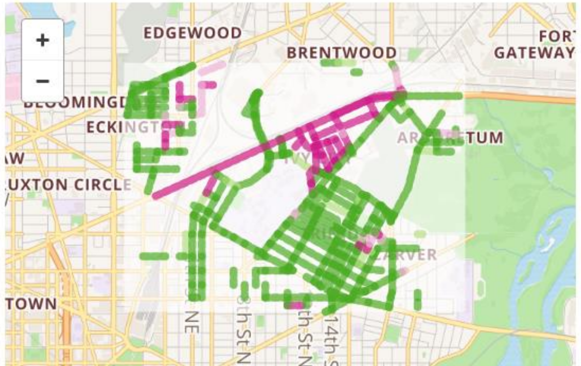
Cross-city comparison tools



Access Features

This API serves point-level location data on accessibility features. The major categories of the features include: "Curb Ramp," "Missing Curb Ramp," "Obstacles," and "Surface Problem." You would occasionally find an accessibility feature like "No Sidewalk."

URL	`/v1/access/features`
Method	GET
Parameters	**Required:** You need to pass a pair of latlng coordinates to define a bounding box, which is used to specify where you want to query the data from. • `lat1=[double]` • `lng1=[double]` • `lat2=[double]` • `lng2=[double]`
Success Response	**200** The API returns all the available accessibility features in the specified area as a Feature Collection of Point features.
Example	`/v1/access/features?lat1=38.909&lng1=-76.989&lat2=38.912&lng2=-76.982`



Access Score: Streets

This API serves Accessibility Scores of the streets within a specified region. Accessibility Score is a numerical value between 0 and 1, where 0 means inaccessible and 1 means accessible.

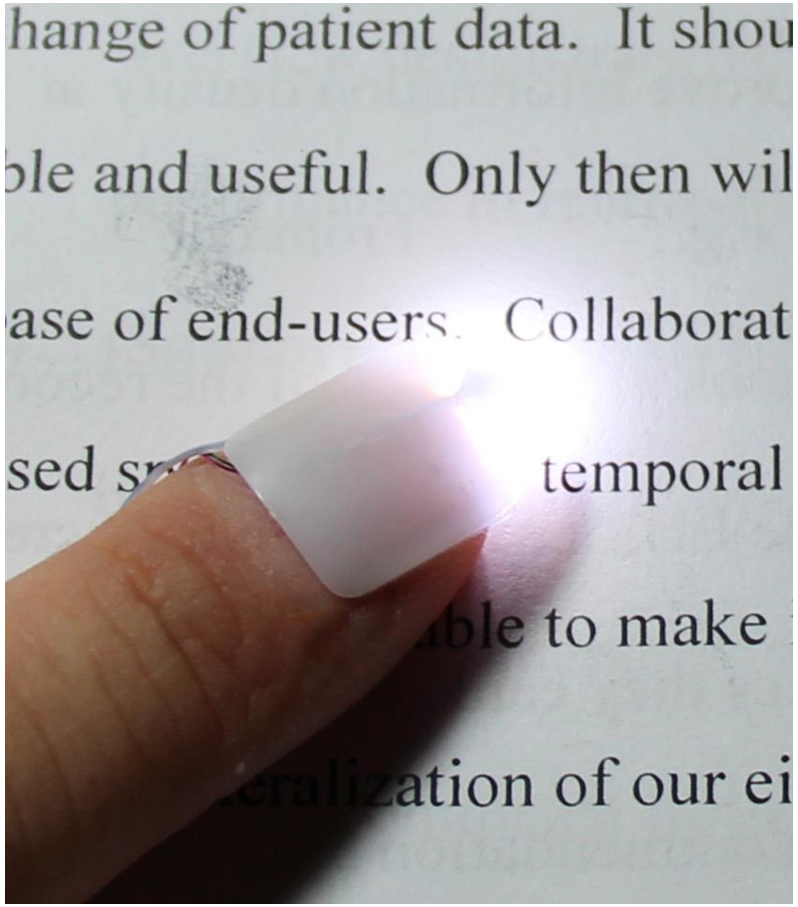
URL	`/v1/access/score/streets`
Method	GET
Parameters	**Required:** You need to pass a pair of latlng coordinates to define a bounding box, which is used to specify where you want to query the data from.

THREAD 1: ACCESSIBILITY

IMPROVING ACCESS TO THE PHYSICAL WORLD

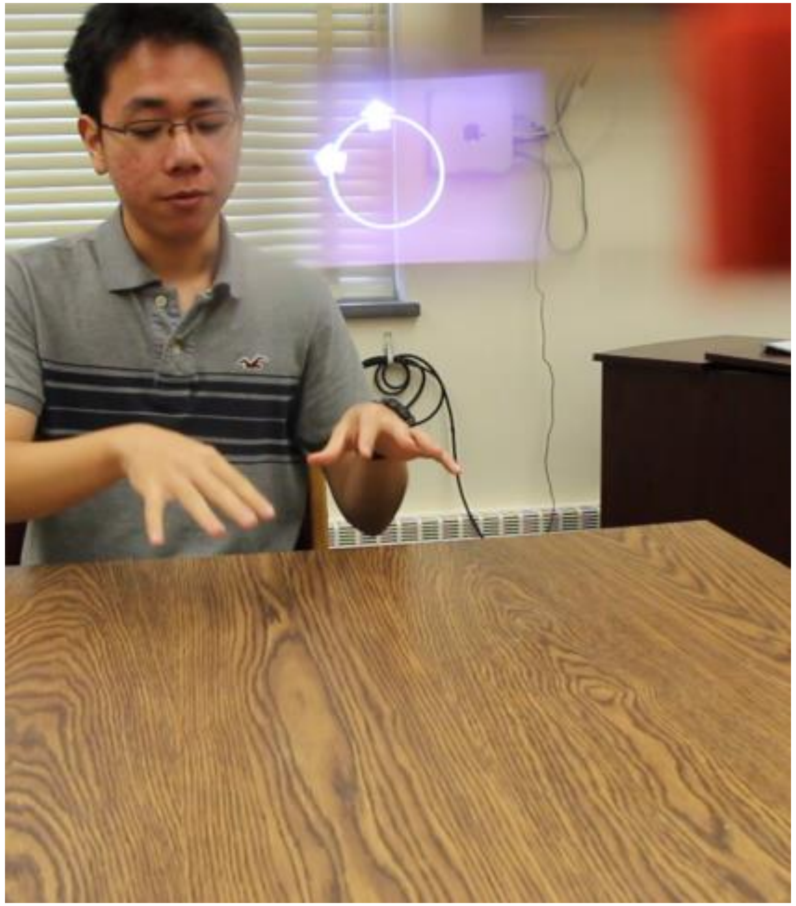
PROJECT SIDEWALK

[ASSETS'12, CHI'13, HCOMP'13, ASSETS'13 Best Paper, UIST'14, TACCESS'15, SIGACCESS'15, CHI'16]



HANDSIGHT

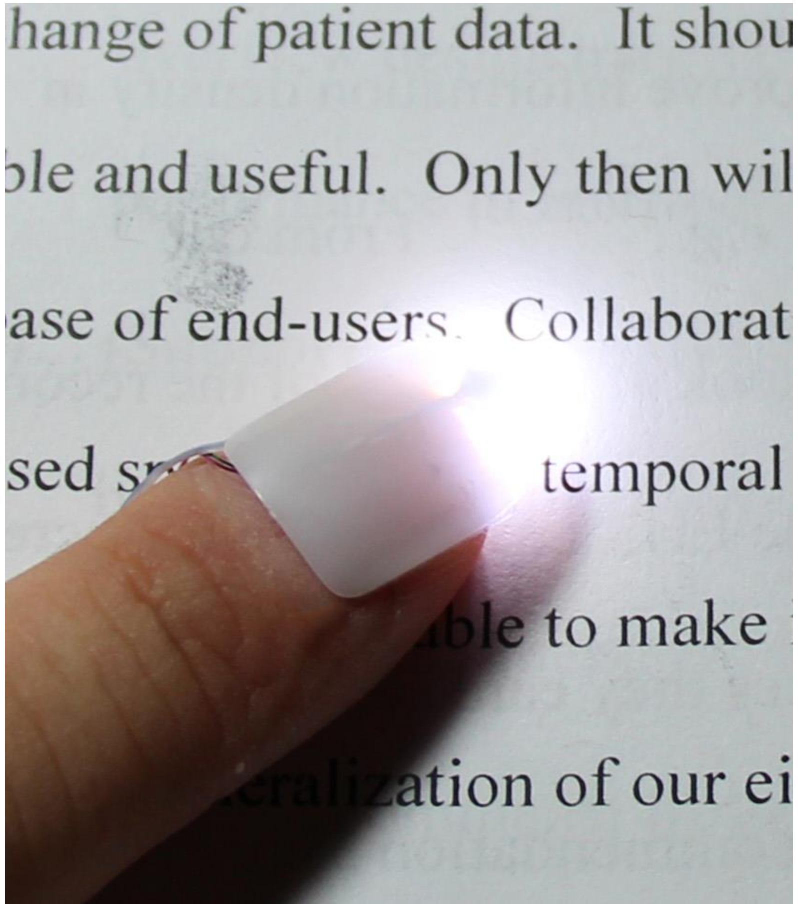
[ACVR'14, ASSETS'15, GI'16, TACCESS'16]



GLASSEAR

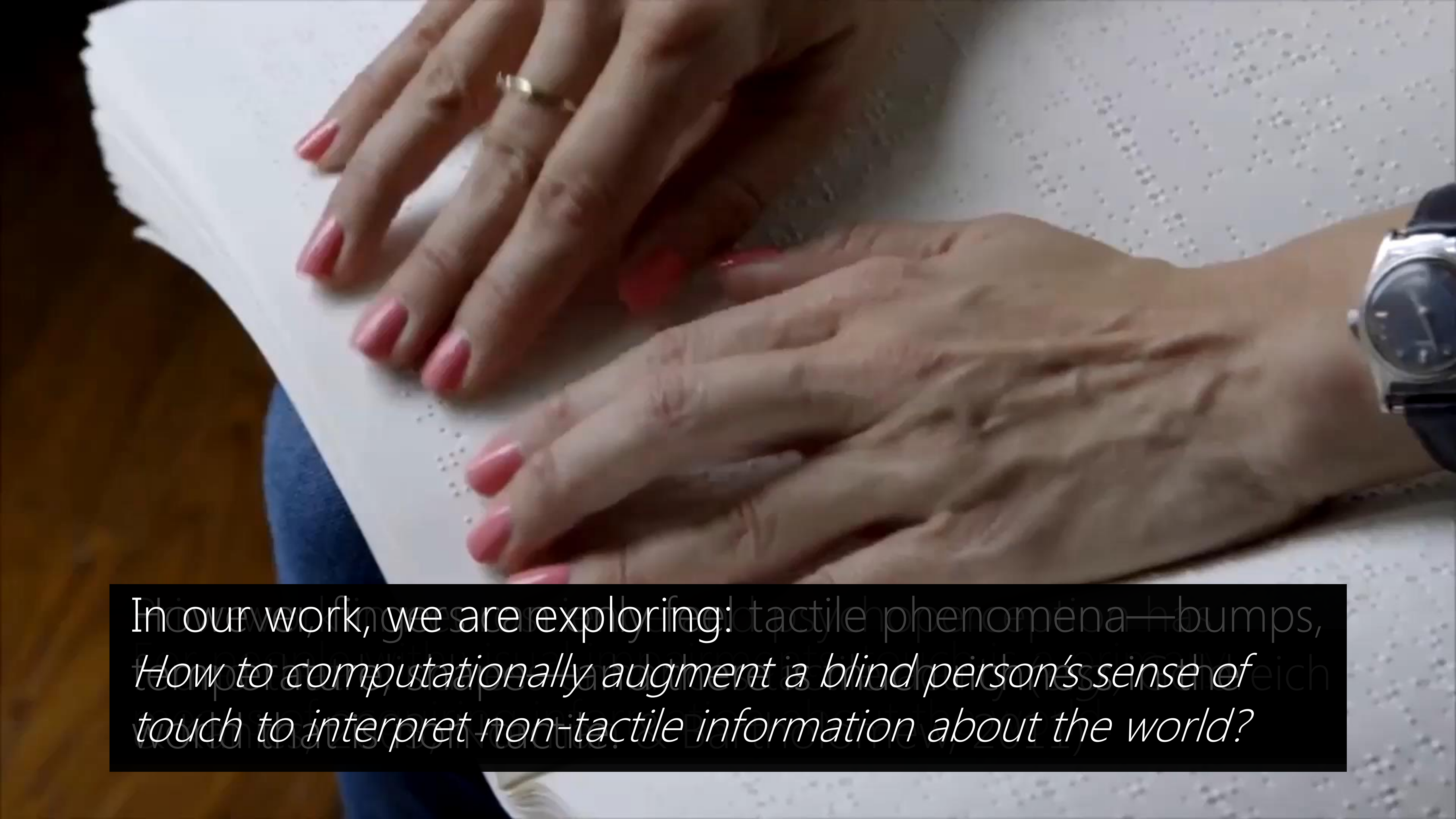
[CHI'15]

IMPROVING ACCESS TO THE PHYSICAL WORLD



HANDSIGHT
[ACVR'14, ASSETS'15, GI'16, TACCESS'16]

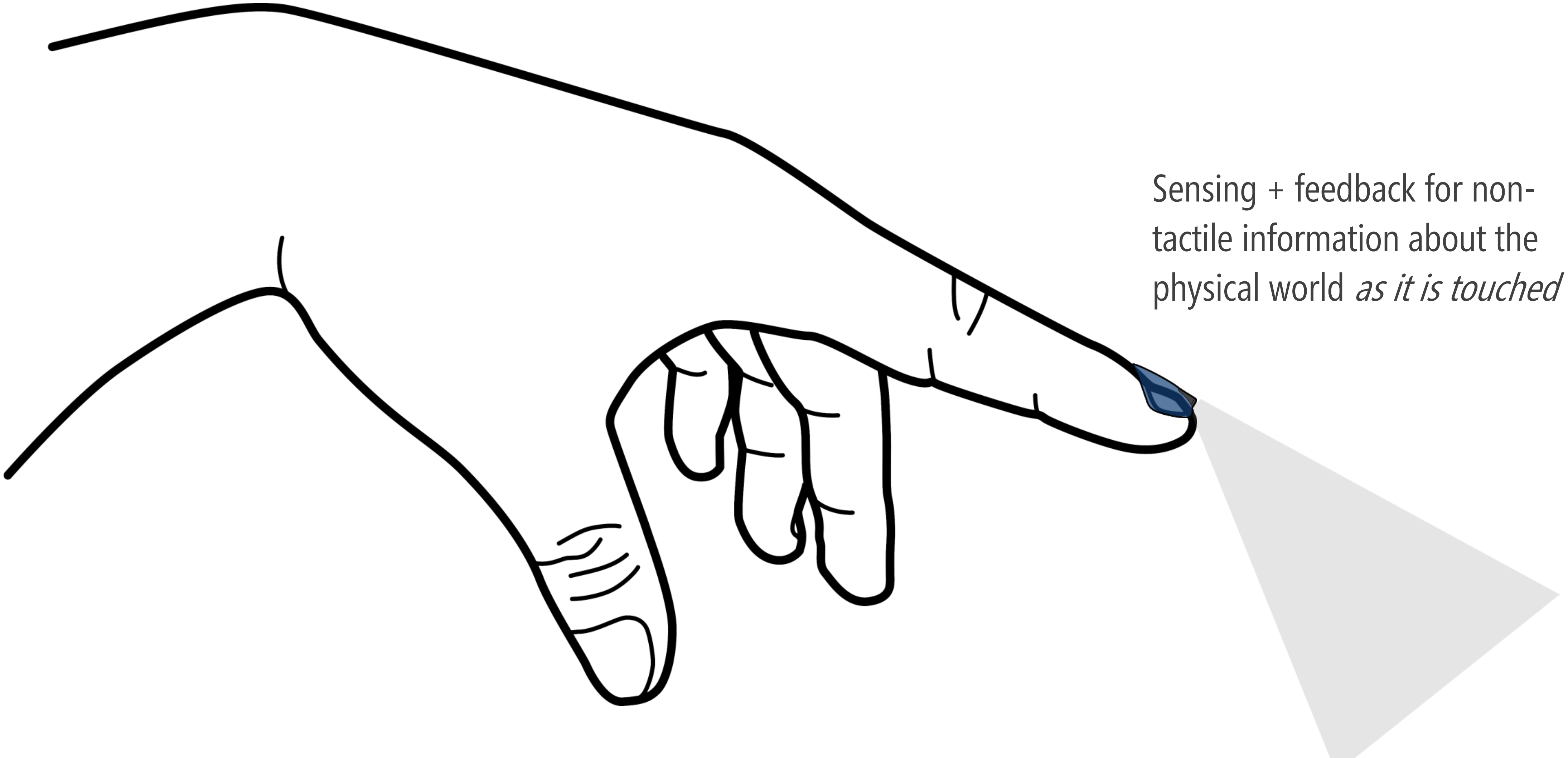
How can we…
we sense & feed back non-tactile information about the physical world *as it is touched*?


In our work, we are exploring:
How to computationally augment a blind person's sense of touch to interpret non-tactile information about the world?

or touching a piece of clothing and hearing a description
of the underlying fabric

VISION-AUGMENTED TOUCH

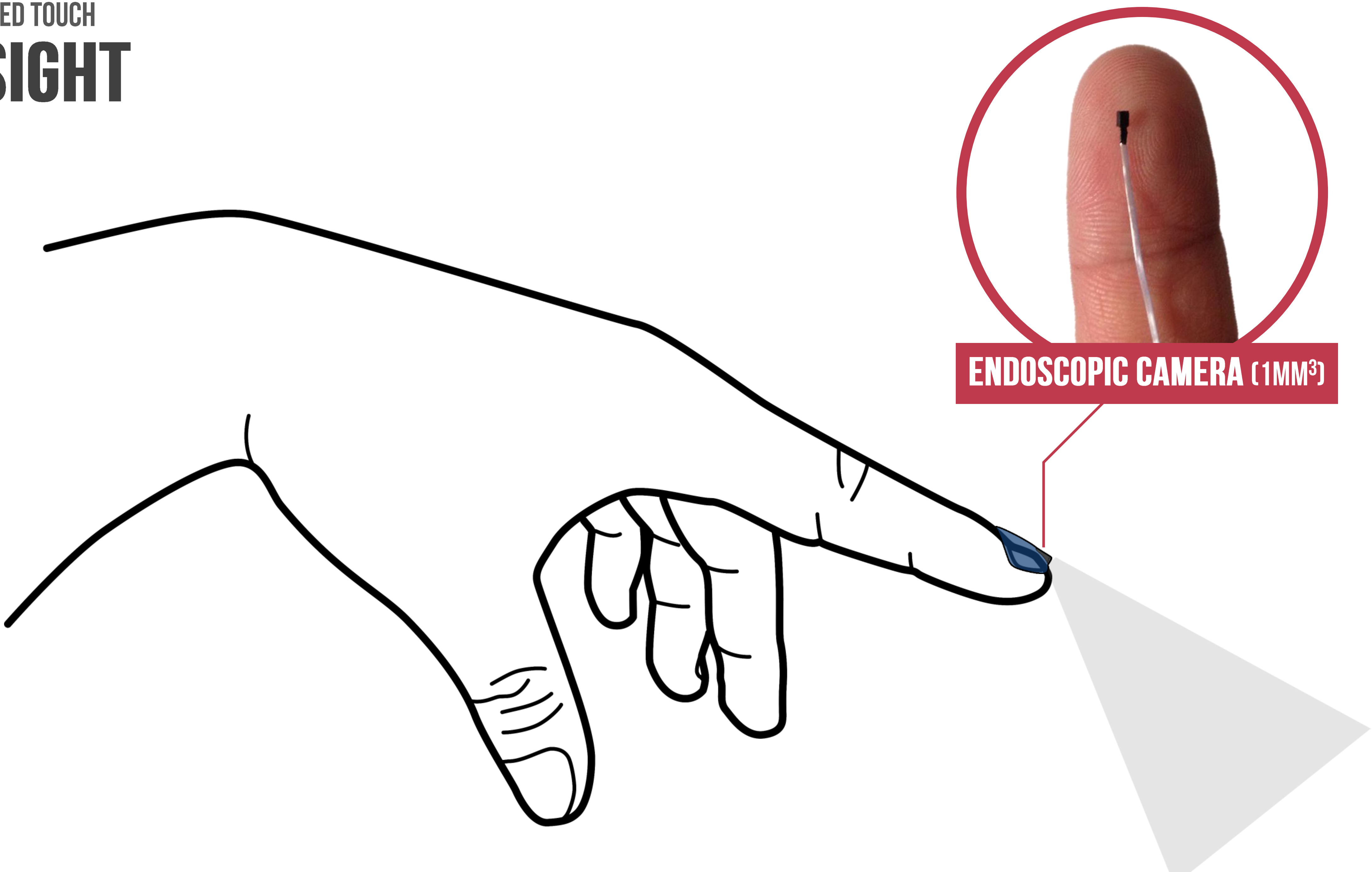
HANDSIGHT



Sensing + feedback for non-tactile information about the physical world *as it is touched*

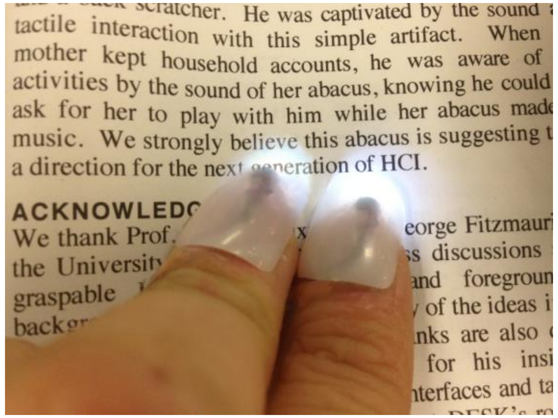
VISION-AUGMENTED TOUCH

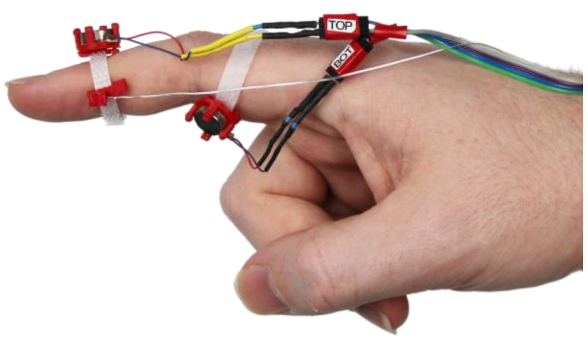
HANDSIGHT

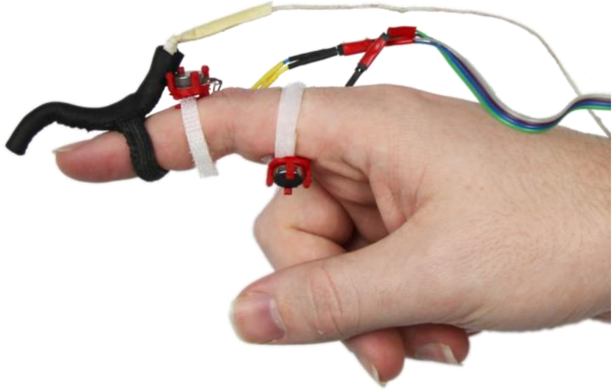


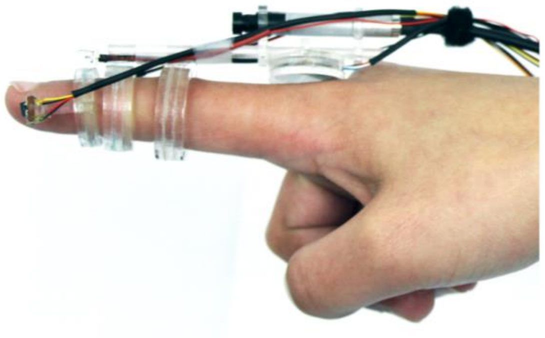
HANDSIGHT

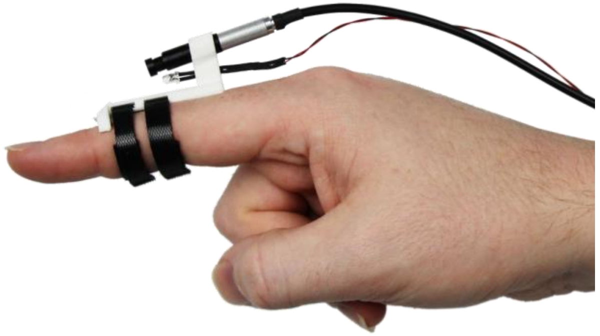
PROTOTYPE EXPLORATIONS

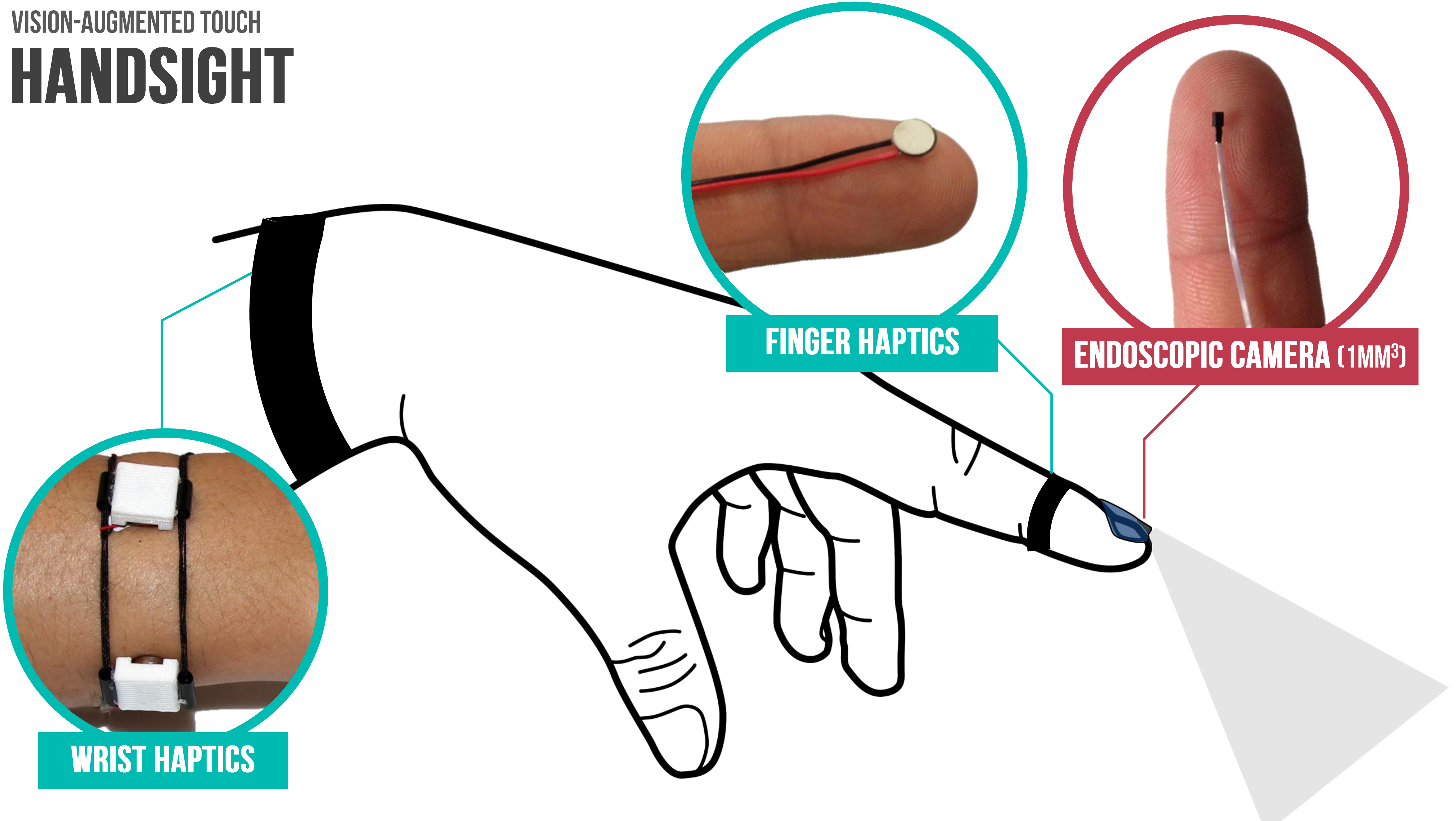






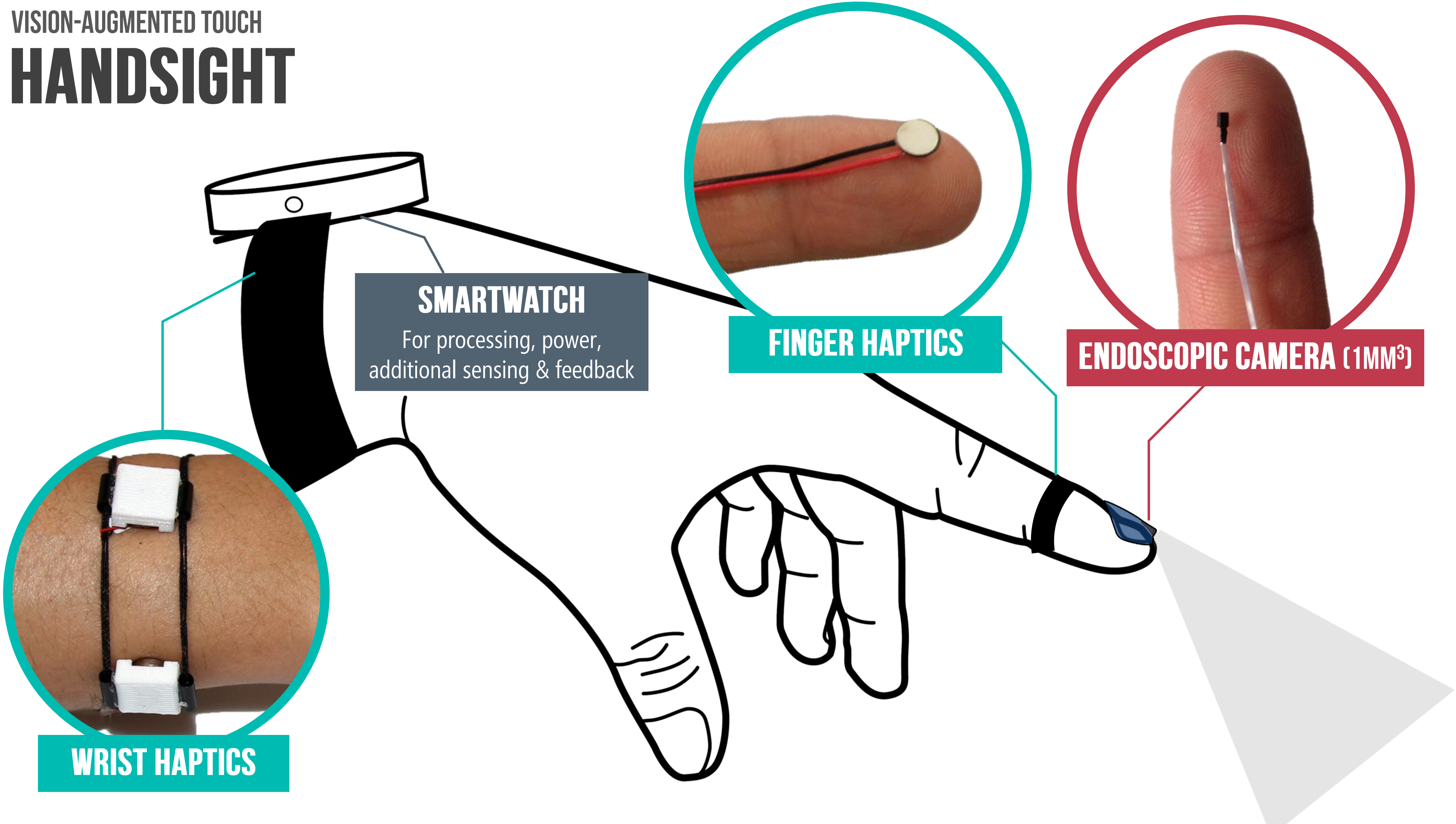





VISION-AUGMENTED TOUCH
HANDSIGHT
FINGER HAPTICS
ENDOSCOPIC CAMERA (1MM³)
WRIST HAPTICS

VISION-AUGMENTED TOUCH

HANDSIGHT

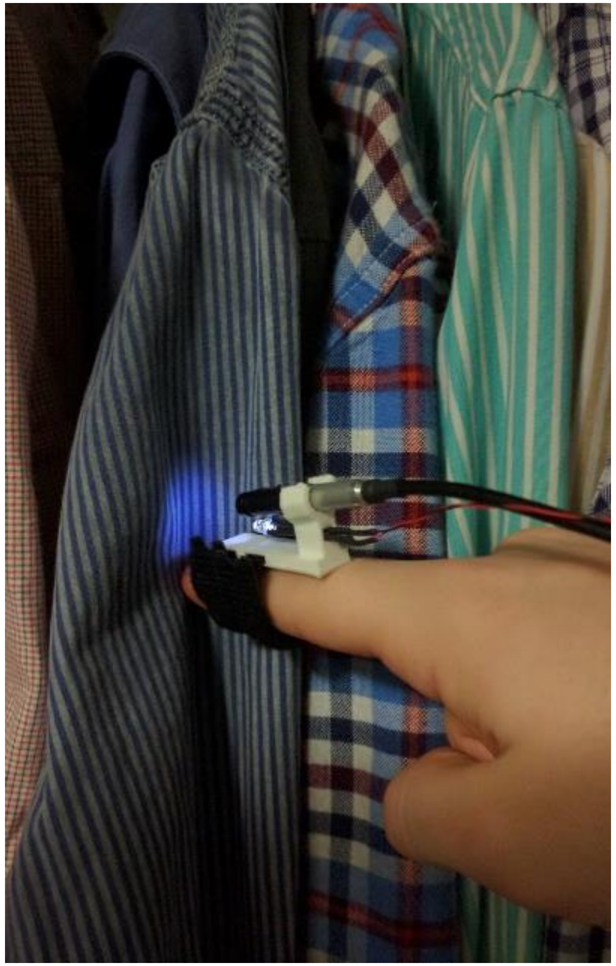


HANDSIGHT

FOCUS AREAS

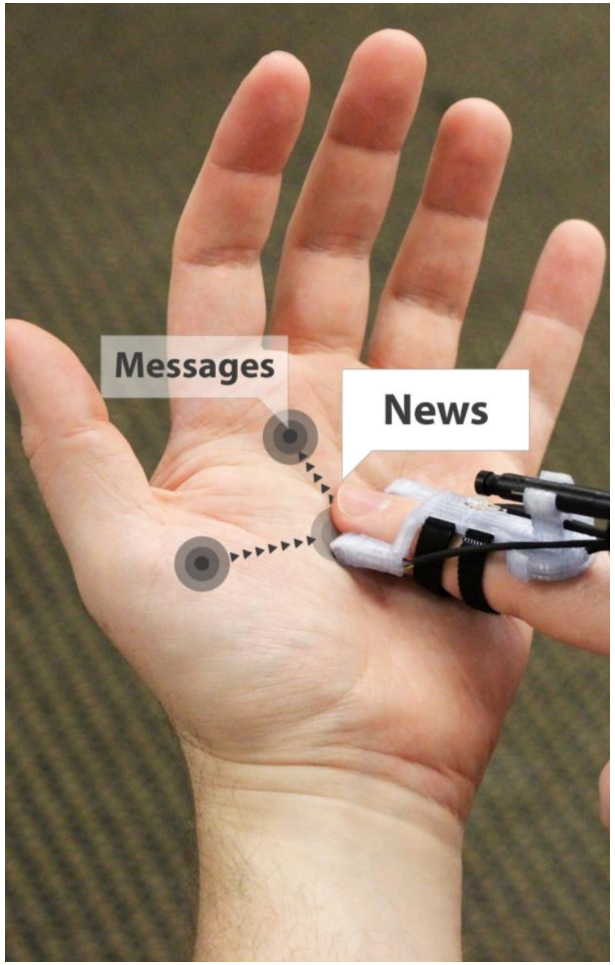
READING SUPPORT

[ACVR'14, TACCESS'15]



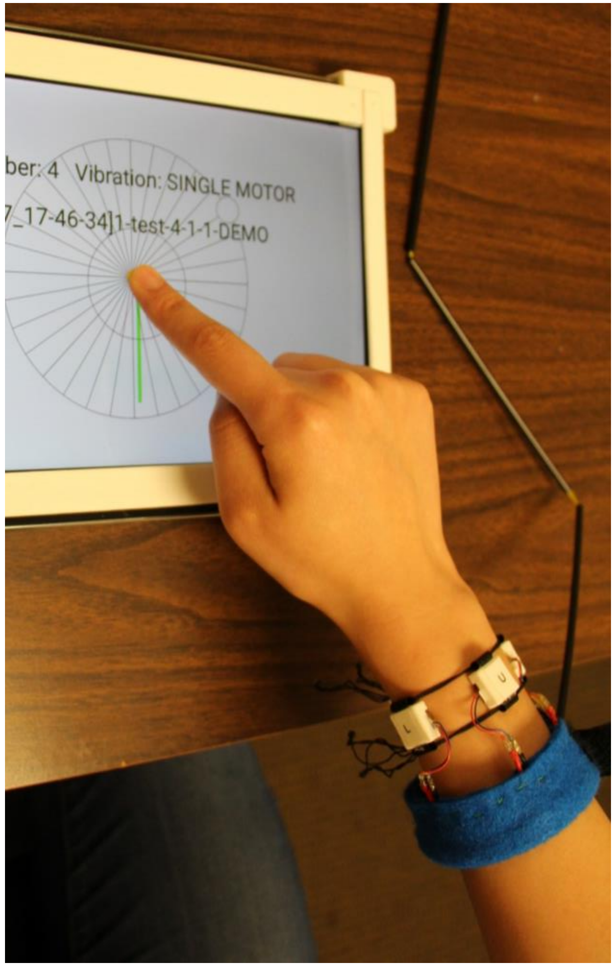
COLOR/TEXTURE RECOGNITION

In progress



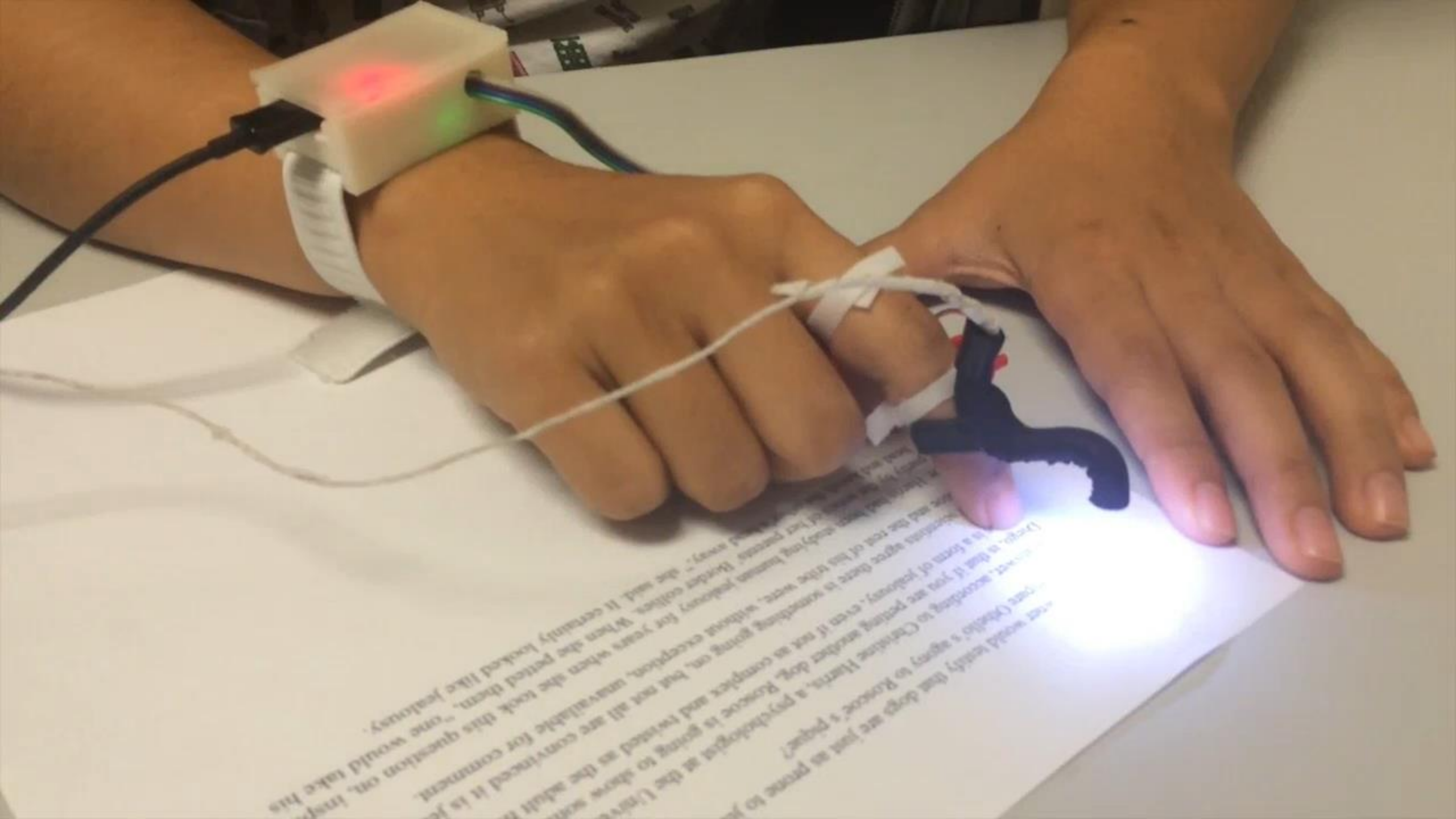
TOUCH-BASED CONTROL

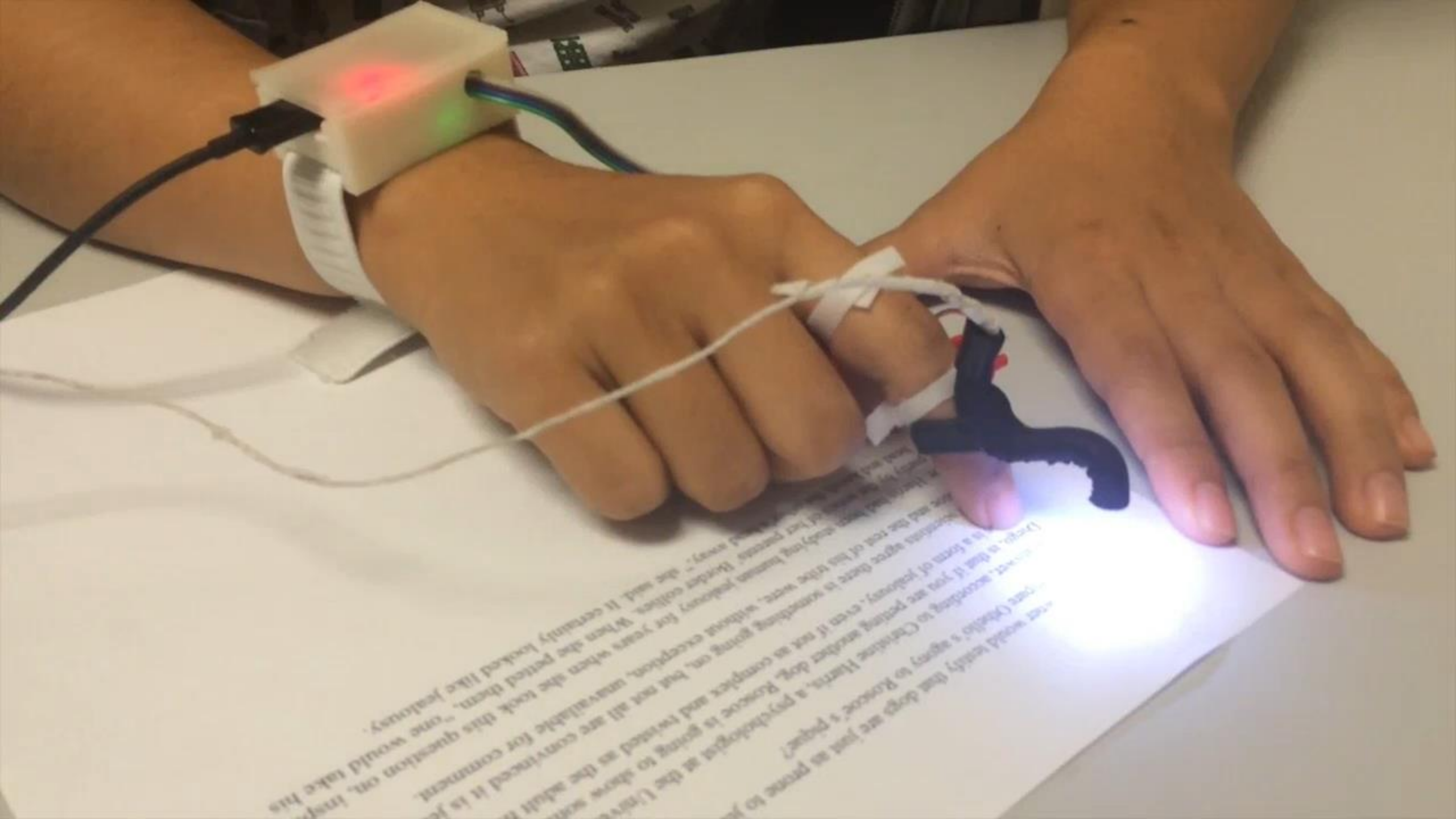
[ICPR'16]



HAPTIC + AUDITORY FEEDBACK

[TACCESS'15, GI'16]


would testify that dogs are just as prone to
Othello's agony to Roscoe's pique?
according to Christine Harris, a psychologist at the
Dogs, is that if you are petting another dog, Roscoe is going to show
is a form of jealousy, even if not as complex and twisted as the adult
agree there is something going on, but not all are convinced it is
and the rest of his tribe were, without exception, unavailable for comment.
studying human jealousy for years when she took this question on,
her parents' Border collies. When she petted them, "one would take his
away," she said. It certainly looked like jealousy.

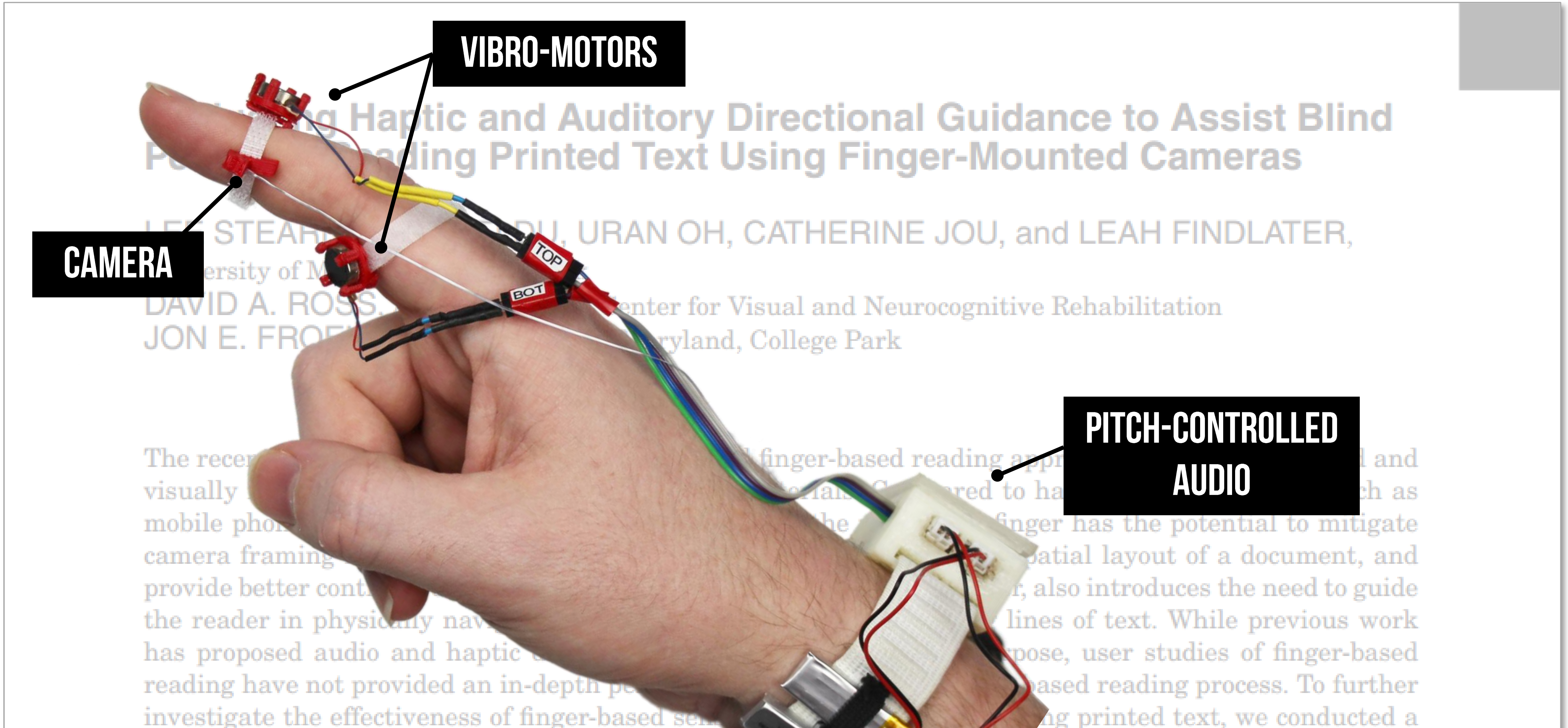



Conclusion
We have run a
Each
particular
a town over a period of days walking around.
strange, consider watching a bird fly close to you
you recognise it as a red cardinal, and then flying into the
distance until it is just a black dot against the sky. You
still know that it is the red cardinal
are telling you this, although
would be strained
was a cardinal,
as it is out of
of it was an act
and in particular
alone would not carry that
to say that you had "learned
when that learning will be discarded
sight: better to say that your
extended over time.) Never
in considering how to
about whether users will
whether they will perce
compared to the general
In what follows we shall
perceptible (at lea
that sort of time.

HANDSIGHT

HAPTIC VS AUDIO LINE GUIDANCE

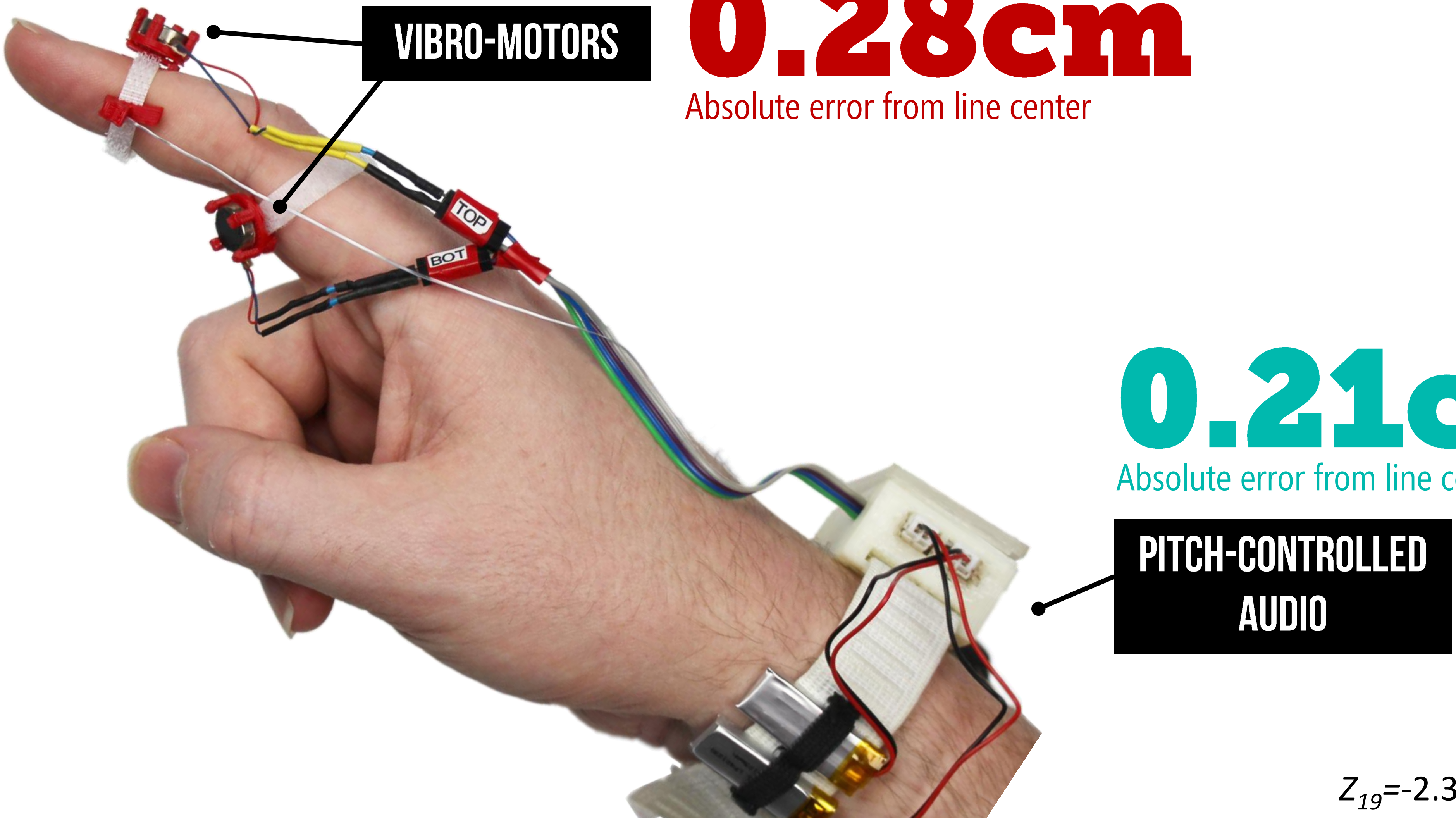
TACCESS'16



HANDSIGHT

HAPTIC VS AUDIO LINE GUIDANCE

TACCESS'16



0.28cm
Absolute error from line center

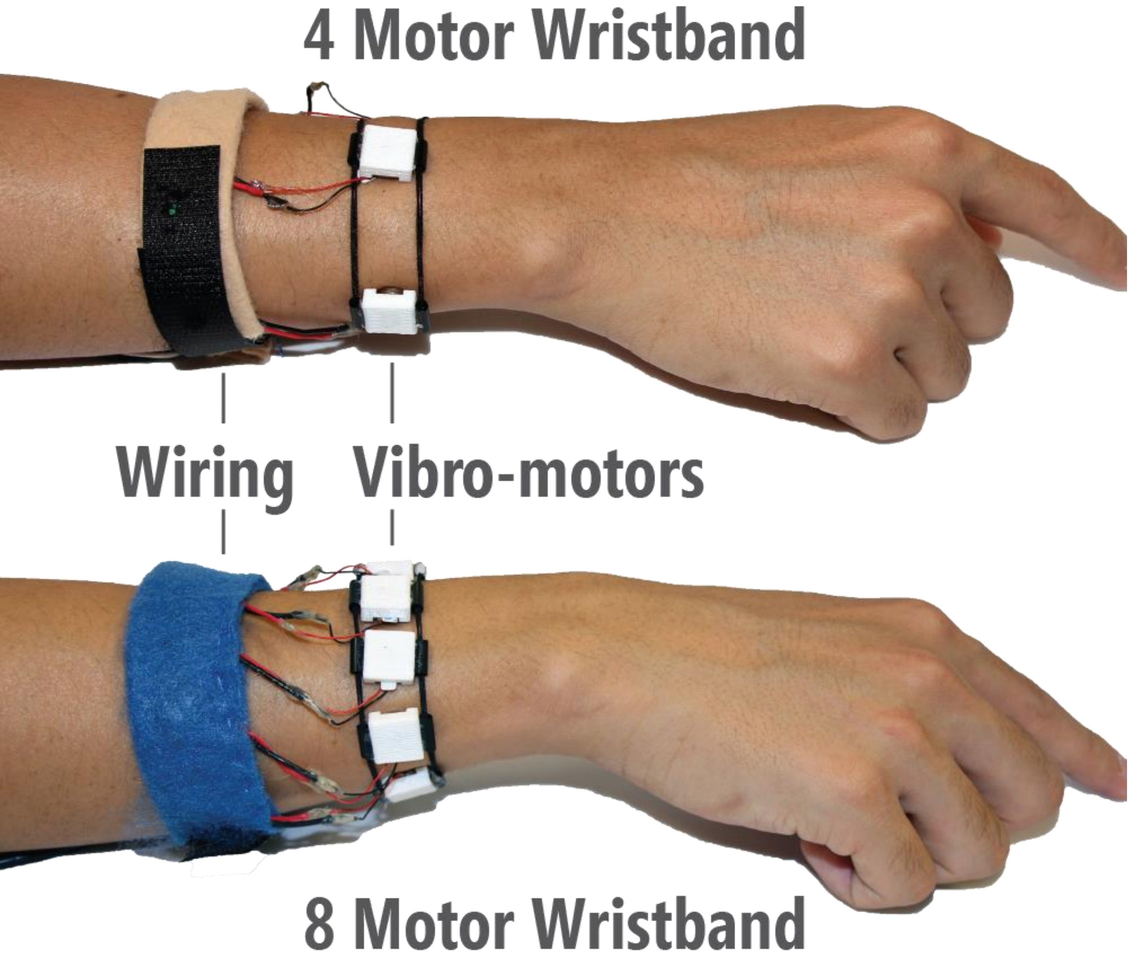
0.21cm
Absolute error from line center

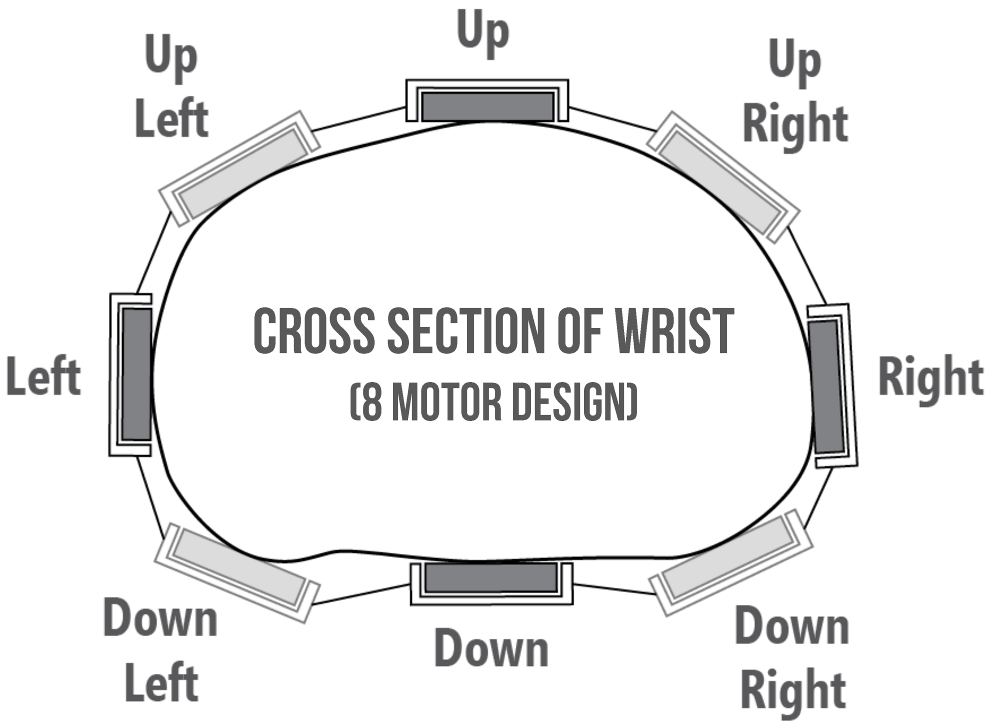
Z_{19}=-2.374, p=.018, r=.54

HANDSIGHT

WRIST HAPTICS

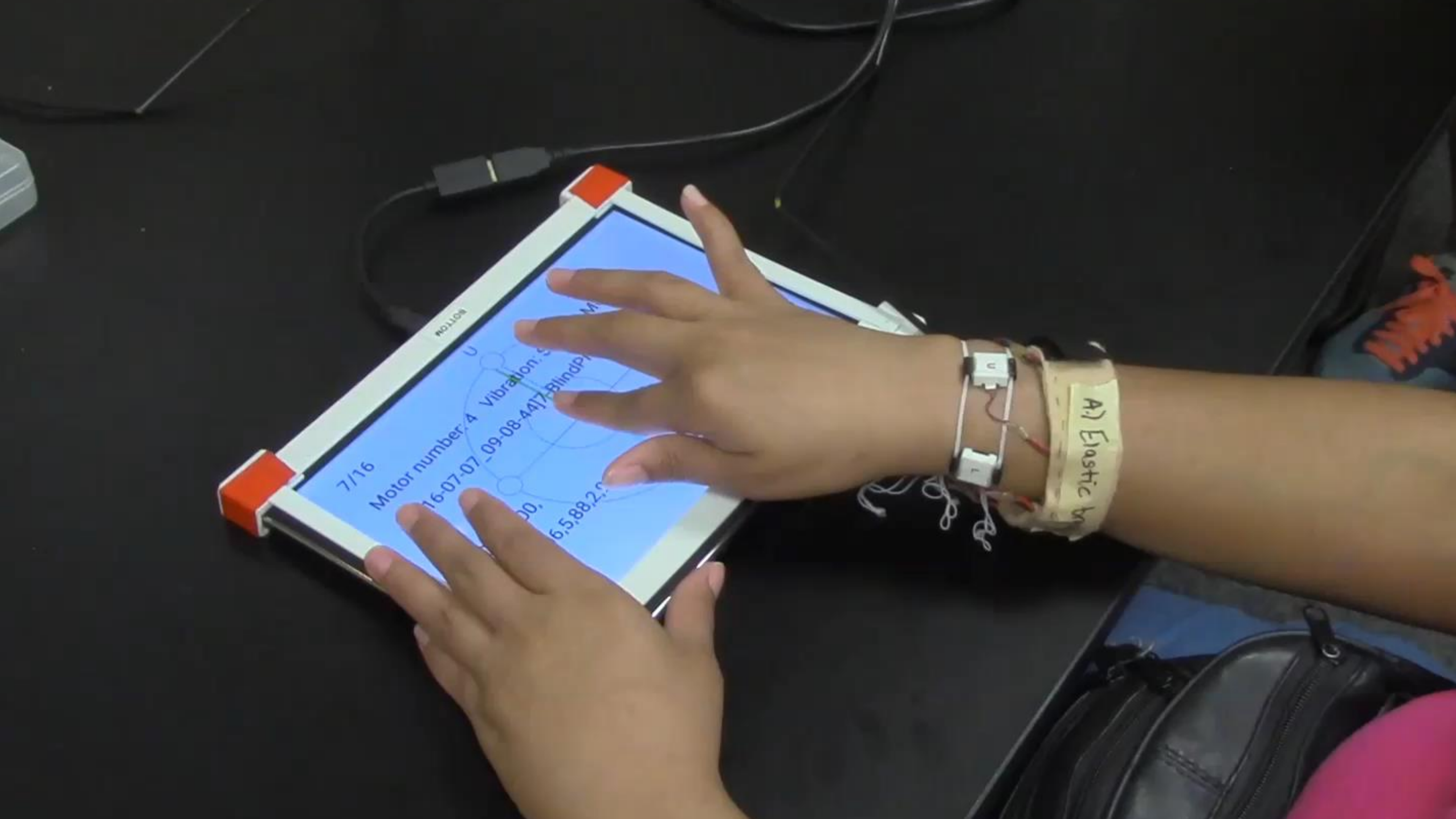
GI'16





TESTED 32 MOVEMENT DIRECTIONS

(11.25° INTERVALS)


7/16
Motor number: 4
BOTTOM

HANDSIGHT

WRIST HAPTIC STUDY RESULTS

GI'16

25.4°

Directional movement error

8-motor wristband resulted in 9% lower movement error

23.2°

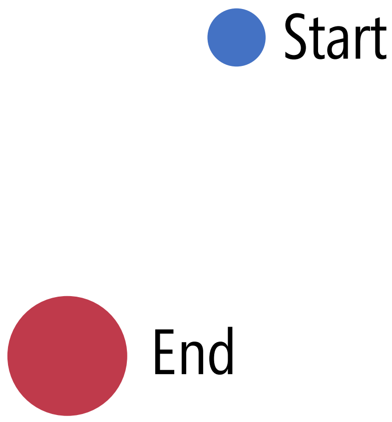
Directional movement error

t_{17}=−1.95, p = .034, d = 0.46

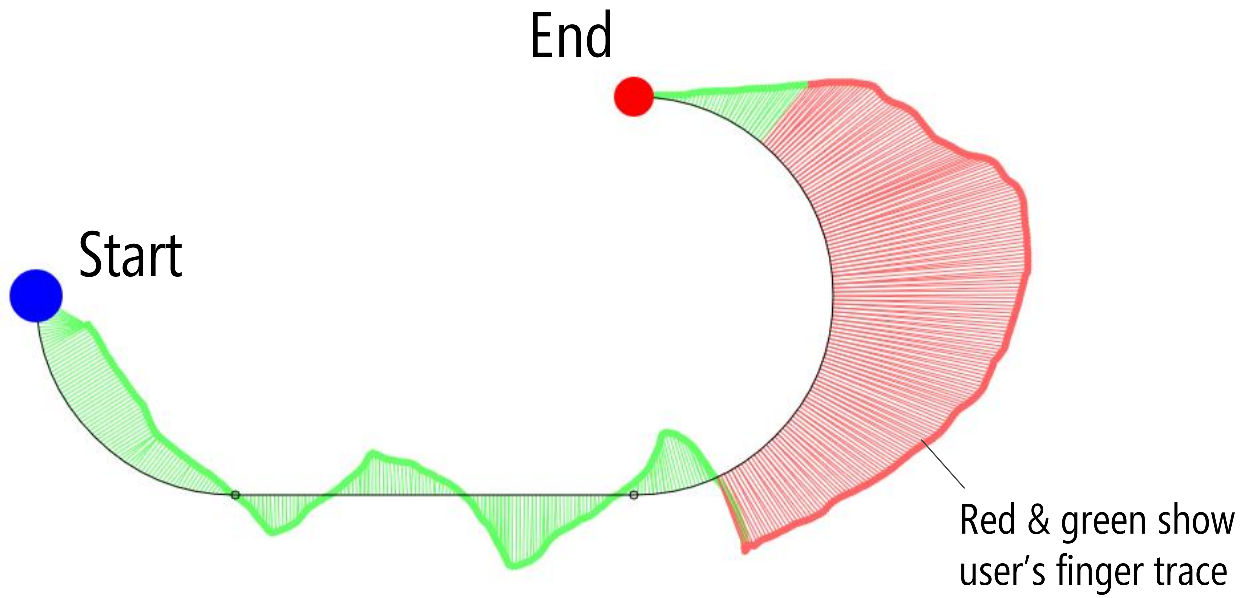
HANDSIGHT

WRIST HAPTICS FOLLOW-UP STUDY

Paper in preparation



TARGET FINDING

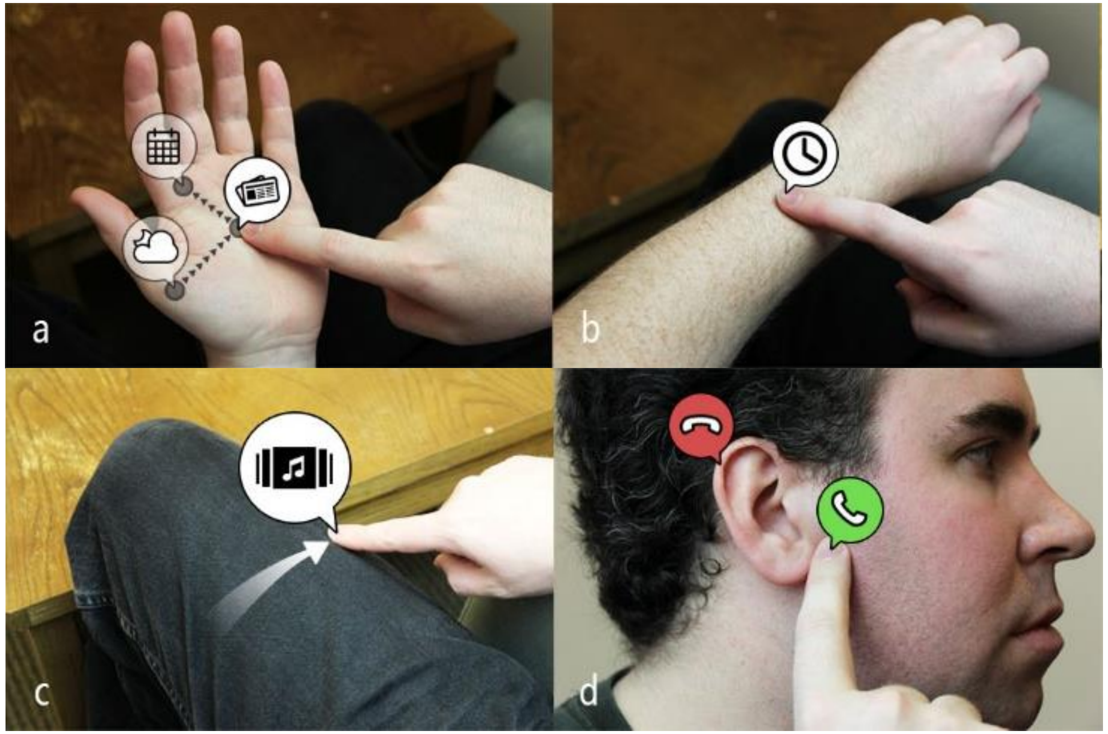


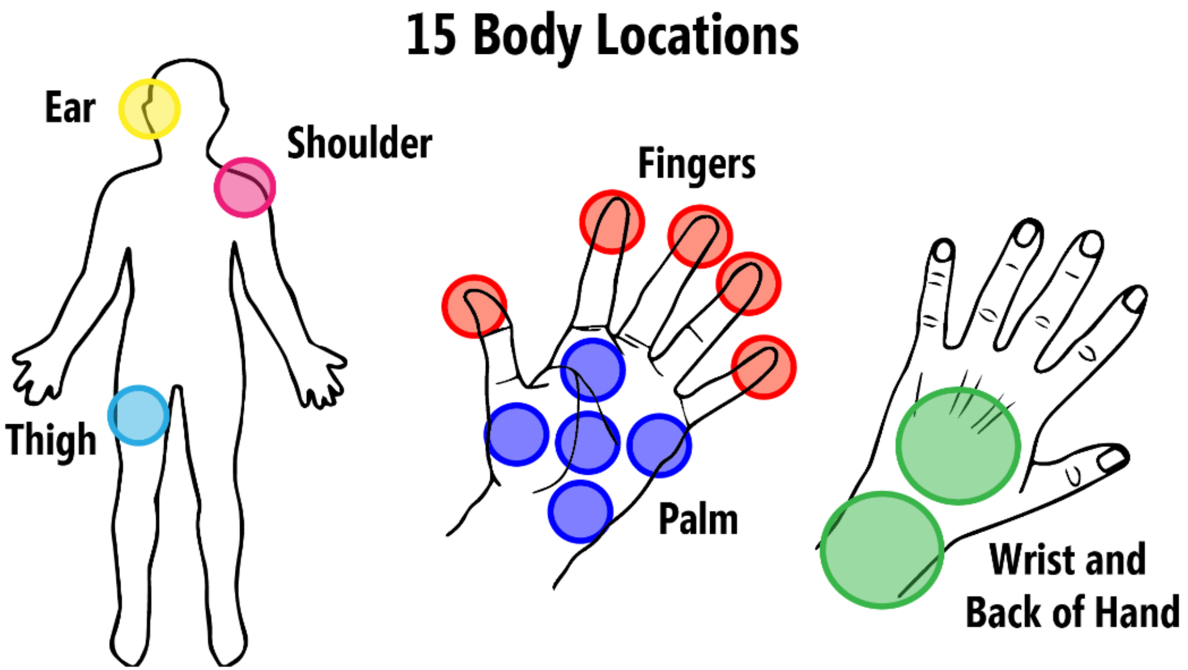
PATH TRACING

HANDSIGHT

ON-BODY INTERACTION FOR VISUALLY IMPAIRED

ICPR'16, two papers in submission






Daily Summary
Clock
Voice Input

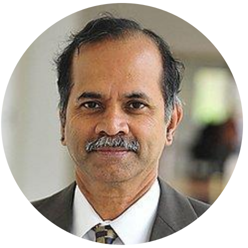

Clock
Voice Input
Health & Activities

HANDSIGHT

THE TEAM

PROFESSORS & RESEARCH ASSOCIATES

Jon Froehlich



Rama Chellappa

Leah Findlater

David Ross

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Lee Stearns

Uran Oh

Jonggi Hong

Ruofei Du

Anis Abboud

UNDERGRADUATE STUDENTS

Meena Sengottuvelu

Alex Medeiros

Harry Vancao

Virginia Melandri

Eric Lancaster

Tony Cheng

Victor Chen

Catherine Jou

Mandy Wang

HIGH SCHOOL STUDENTS

Ji Hyuk Bae

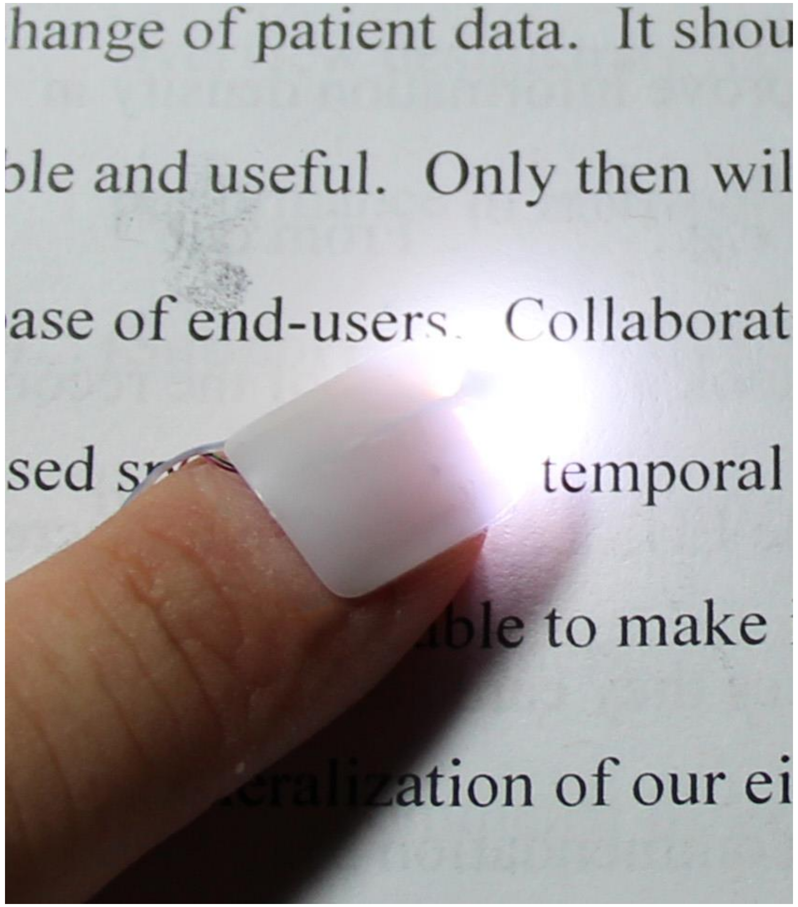
Jessica Yin

Chuan Chen

IMPROVING ACCESS TO THE PHYSICAL WORLD

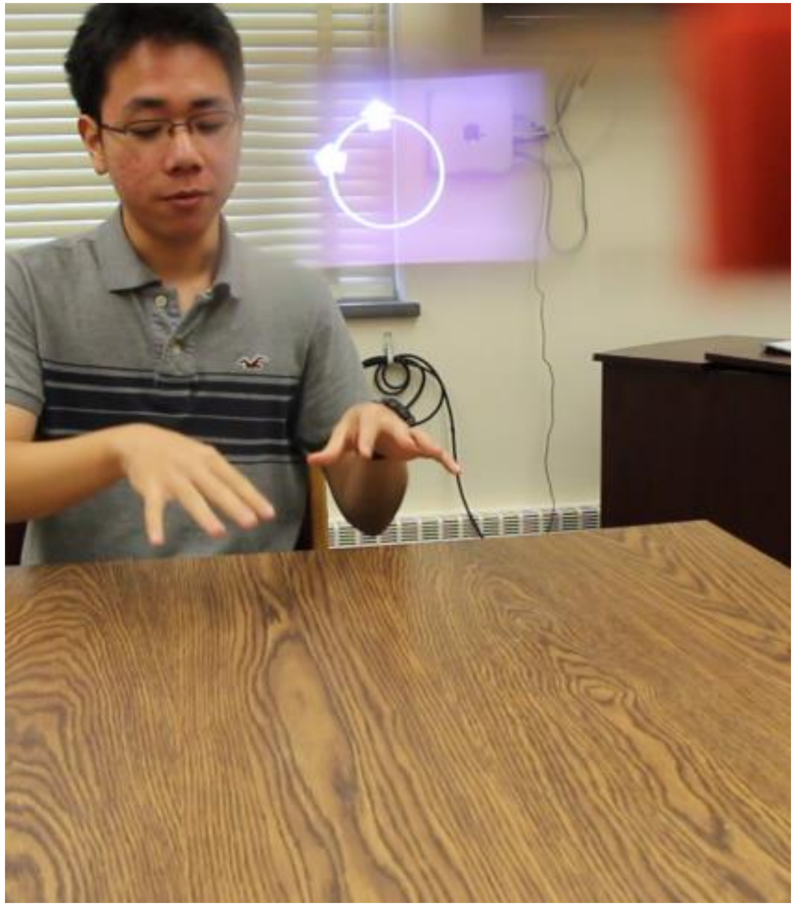
PROJECT SIDEWALK

[ASSETS'12, CHI'13, HCOMP'13, ASSETS'13 Best Paper, UIST'14, TACCESS'15, SIGACCESS'15, CHI'16]



HANDSIGHT

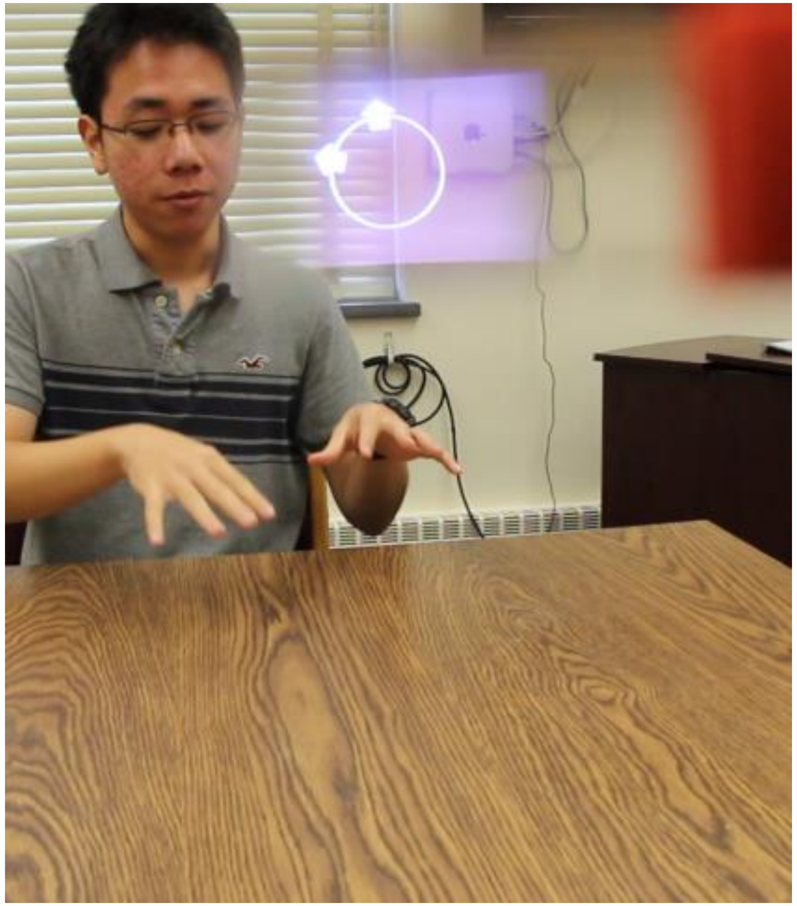
[ACVR'14, ASSETS'15, GI'16, TACCESS'16]



GLASSEAR

[CHI'15]

IMPROVING ACCESS TO THE PHYSICAL WORLD



GLASSEAR
[CHI'15]

How can we...
we sense & visualize sound information on an HMD to improve sound awareness for people who are deaf or hard of hearing?

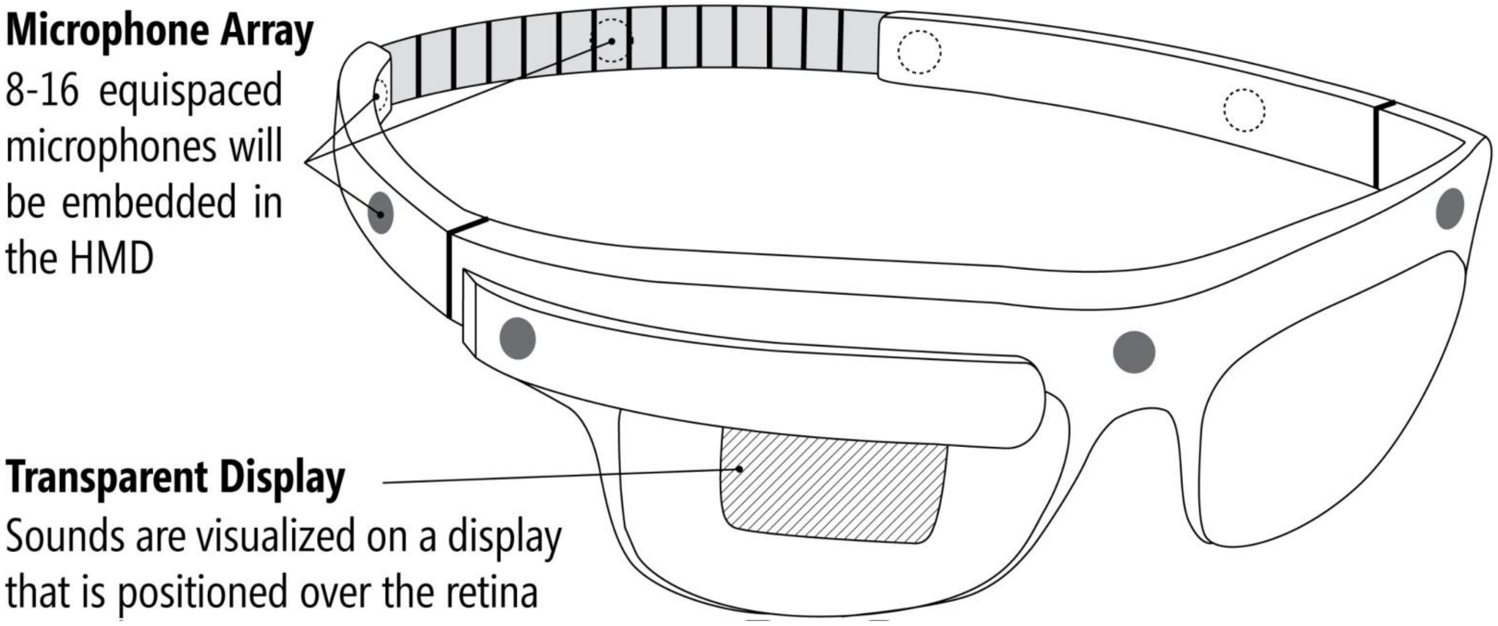

HMD CONVEYS SOUND DIRECTION & MAGNITUDE


NON-WEARABLE
MICROPHONE ARRAY
HMD DISPLAY

Current & Future Work

GLASSEAR

Collaborators: Leah Findlater, Ramani Duraiswami, Dmitry Zotkin, Christian Vogler, & Raja Kushalnager



MAJOR OBJECTIVES:

True wearable design

Precise localization & sound separation algorithms

Oral conversation support

Visualization design

GLASSEAR

THE TEAM

PROFESSORS & RESEARCH ASSOCIATES


Jon Froehlich


Leah Findlater


Ramani Duraiswami


Dmitry Zotkin


Christian Vogler


Raja Kushalnagar

GRAD STUDENT


Dhruv Jain

HIGH SCHOOL STUDENTS


Jamie Gilkeson


Benjamin Holland

MAKEABILITY LAB

FOUR FOCUS AREAS

ENVIRONMENTAL SUSTAINABILITY

HEALTH & WELLNESS

ACCESSIBILITY

STEM EDUCATION

MAKEABILITY LAB

FOUR FOCUS AREAS

ENVIRONMENTAL SUSTAINABILITY

HEALTH & WELLNESS

ACCESSIBILITY

STEM EDUCATION

National Research Council, *A Framework for K-12 Science Education*, 2012

See: Barton, *et al.,* 2008; Naiser & Hand, 2008; Kafai, *et al.,* 2014;


RONJA
Kirjojen
tapahtuma
paikkoja

ENVIRONMENTAL SUSTAINABILITY

HEALTH & WELLNESS

ACCESSIBILITY

STEM EDUCATION

How can we…

design wearables that engage and scaffold children in life-relevant, personally meaningful STEM learning experiences.

POTENTIAL OF WEARABLES TO SUPPORT LEARNING

Unprecedented amount of data

Inherently personalized & life-relevant

Can go where the child goes

Engages the body in learning *(i.e., "embodied learning"*

Pecher, 2005; Lindgren, 2013; Lee, 2014)

THREAD 2: STEM EDUCATION

ENABLING NEW STEM LEARNING EXPERIENCES WITH WEARABLES

BODYVIS
[IDC'13, CHI'15 Honorable Mention, ICLS'16, IDC'16, CHI'17]

MAKERWEAR
[IDC'15, CHI'16 Best Poster, CHI'17 Best Paper]

Complex Problems


ELEMENTARY SCHOOL TEACHERS
BODYVIS DESIGN IDEAS &
INITIAL LEARNING ACTIVITIES

ENABLING NEW STEM LEARNING EXPERIENCES WITH WEARABLES

BODYVIS
[IDC'13, CHI'15 Honorable Mention, ICLS'16, IDC'16, CHI'17]

How can we...
design wearables that use the human body and physical activity as a platform for experimentation & scientific inquiry?

"Does my heart beat faster when running vs. reading a book? Why?"

"How does my breathing rate compare to my classmate's and why may this be?"

"How does food travel through my body?"

ADVANCING SCIENCE LEARNING & INQUIRY EXPERIENCES THROUGH WEARABLES

BODYVIS TEAM

PROFESSORS

Jon Froehlich

Tamara Clegg

GRAD STUDENTS

Leyla Norooz

Seokbin Kang

Virginia Byrne

Rafael Velez

Amy Green

UNDERGRADUATE STUDENTS

Monica Katzen

Angelisa Plane

Vanessa Oguamanam

Thomas Outing

Anita Jorgensen

HIGH SCHOOL STUDENT

Sage Chen

BODYVIS PROTOTYPES

PROTOTYPE 1: MID-FI

Stuffed fabric organs
Heartrate Only
LEDs, EL-Wire
Arduino Uno

PROTOTYPE 2

Improved Anatomy
Heartrate, Breathing
LEDs
Lilypad Arduino

PROTOTYPE 3

Labeled, Removable Anatomy
Heartrate, Breathing, Digestion
LEDs, Sound, Touchscreen
Arduino Uno, Smartphone

PROTOTYPE 4: HI-FI

Added Organs (*e.g.,* Bladder)
Heartrate, Breathing, Digestion
LEDs, Sound, Haptics, Touchscreen
Arduino BLE Mini, Smartphone

BODYVIS PROTOTYPES

PROTOTYPE 1

Stuffed fabric organs
Heartrate Only
LEDs, EL-Wire
Arduino Uno

PROTOTYPE 2

Improved Anatomy
Heartrate, Breathing
LEDs
Lilypad Arduino

PROTOTYPE 3

Labeled, Removable Anatomy
Heartrate, Breathing, Digestion
LEDs, Sound, Touchscreen
Arduino Uno, Smartphone

PROTOTYPE 4

Added Organs (*e.g.,* Bladder)
Heartrate, Breathing, Digestion
LEDs, Sound, Haptics, Touchscreen
Arduino BLE Mini, Smartphone


Optical heart rate sensor

BODYVIS: FOUR GENERATIONS

PROTOTYPE 1

Stuffed fabric organs
Heartrate Only
LEDs, EL-Wire
Arduino Uno

PROTOTYPE 2

Improved Anatomy
Heartrate, Breathing
LEDs
Lilypad Arduino

PROTOTYPE 3

Labeled, Removable Anatomy
Heartrate, Breathing, Digestion
LEDs, Sound, Touchscreen
Arduino Uno, Smartphone

PROTOTYPE 4

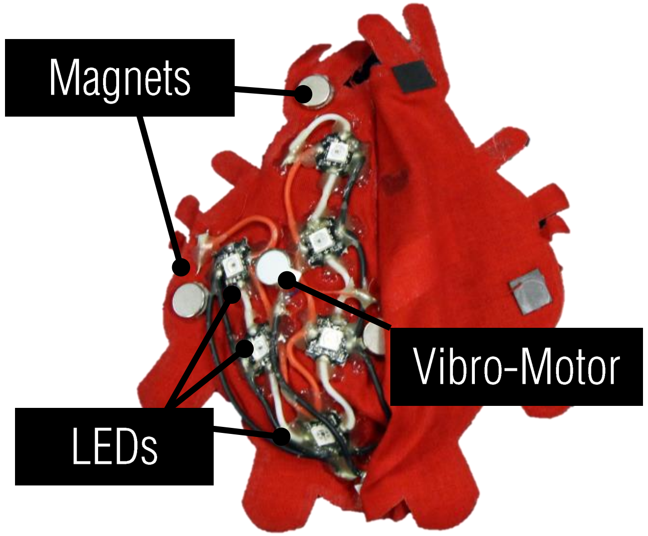
Added Organs (*e.g.,* Bladder)
Heartrate, Breathing, Digestion
LEDs, Sound, Haptics, Touchscreen
Arduino BLE Mini, Smartphone


Snack time!
Esophagu
Lung
Lung
Liver
Large Intestine
Small Intestine
The heart and lungs visualize wearers' live heart and breathing rate.

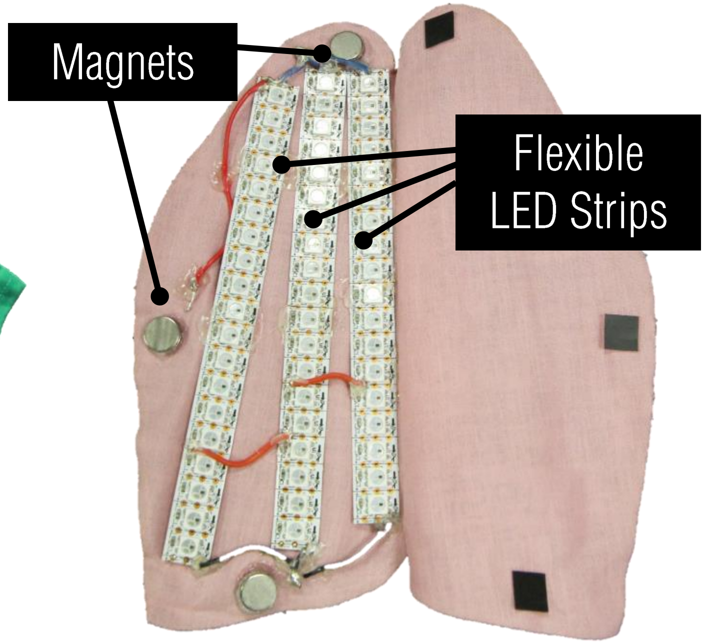
BODYVIS

HOW IT WORKS

HEART



LUNGS

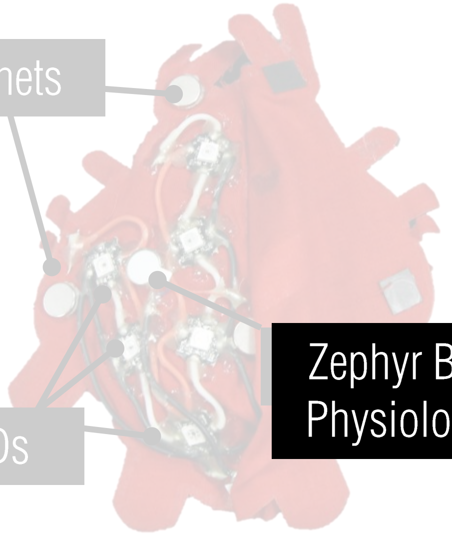


STOMACH

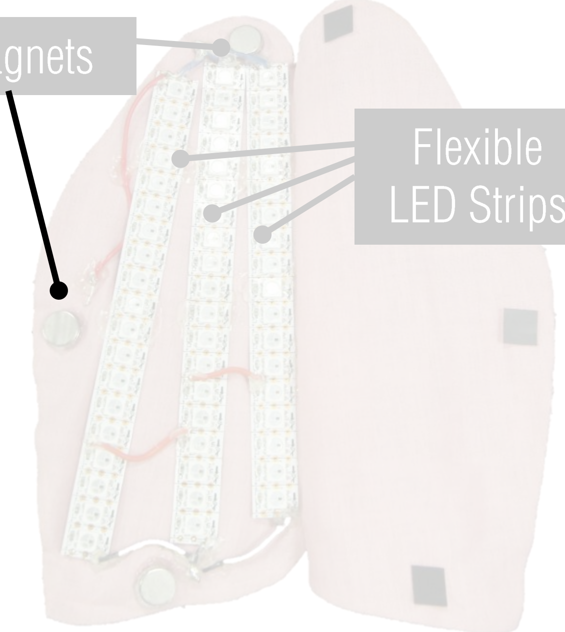
BODYVIS

HOW IT WORKS

HEART



LUNGS



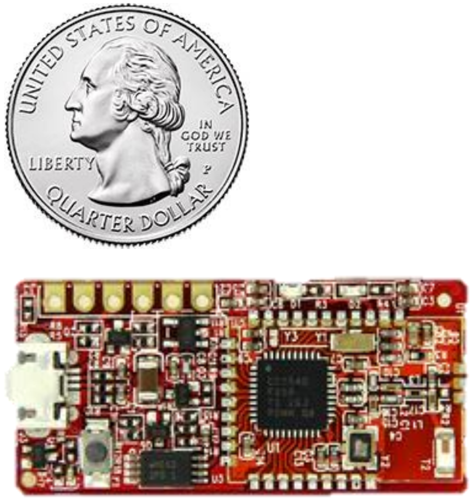
STOMACH

BODYVIS

SENSING SYSTEM

Wirelessly transmits
via Bluetooth

Wirelessly transmits
via BLE



ZEPHYR BIOHARNESS 3

Worn directly on skin
Senses heart, breathing, movement

SAMSUNG GALAXY S4 MINI

Serves as stomach
Processes physiological data
Plays sound & vibrates

REDBEARLAB BLE MINI ARDUINO

Sewn into shirt
Directly wired to LEDs, Vibro-motors,
digestion button, etc.

EVALUATIONS (N=200)

TEACHER INTERVIEWS

AFTER-SCHOOL PROGRAMS

SCIENCE CAMPS

ELEMENTARY SCHOOLS

FINDINGS

Overall reactions

BodyVis interactions & experiments

Learning potential

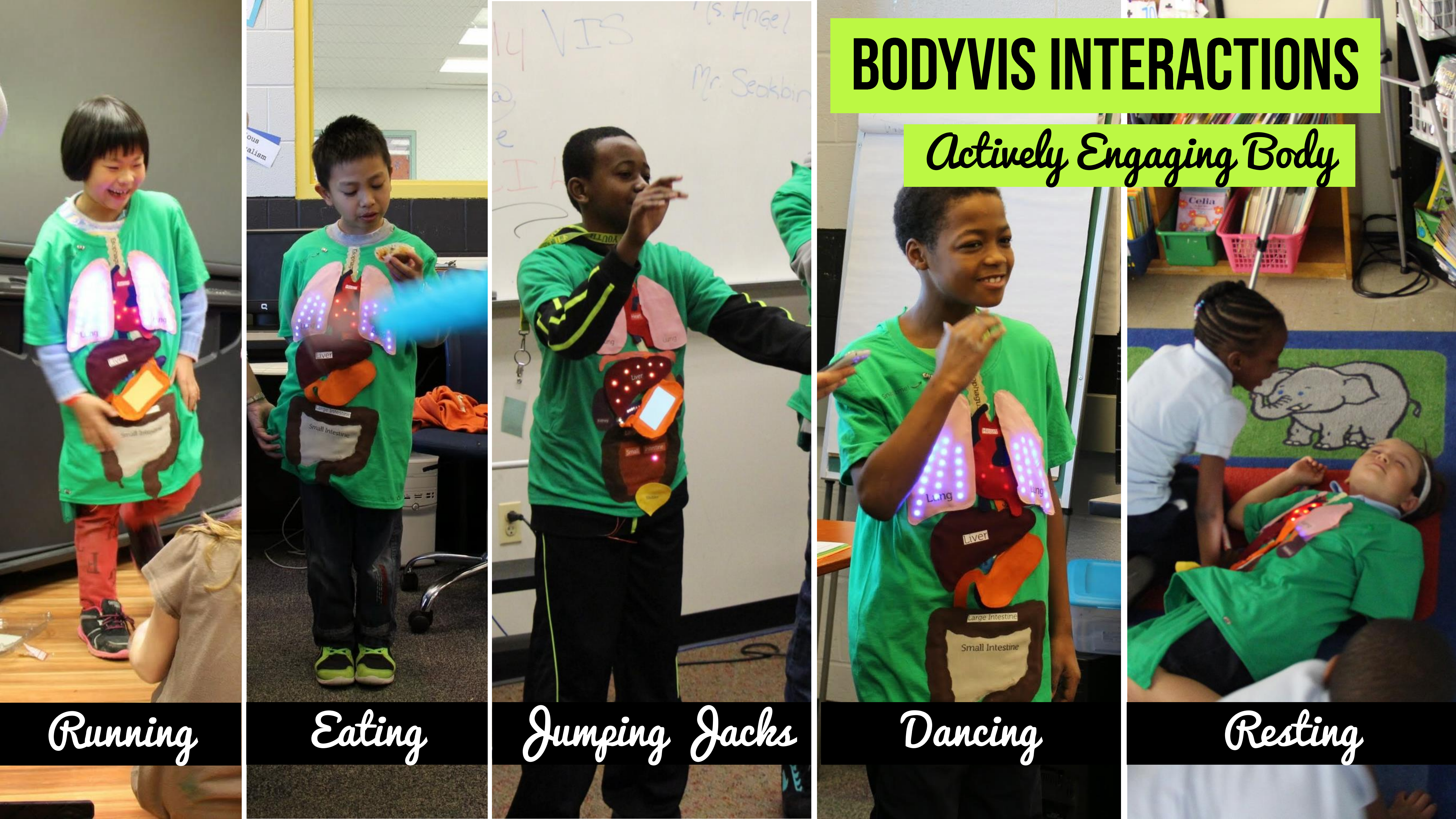
Unexpected things

OVERALL REACTIONS

High Engagement

OVERALL REACTIONS

High Engagement


BODYVIS INTERACTIONS
Actively Engaging Body
Running
Eating
Jumping Jacks
Dancing
Resting

LEARNING POTENTIAL

Pre- & Post-Questionnaires

LEARNING POTENTIAL

Body Map Drawing: Before & After

Body map drawing method: Cuthbert, 2000; Garcia-Barros *et al.*, 2011

LEARNING POTENTIAL

Body Map Drawing: Before & After

73%
Included at least one new organ

56%
Corrected positions of organs

30%
Improved organ shapes

I now want to touch on two unexpected findings


UNEXPECTED FINDING 1
Disembodied Use
GREAT FUTURES START HERE!
Her physiology visualized on shirt
She's wearing sensor

SHAREDPHYS

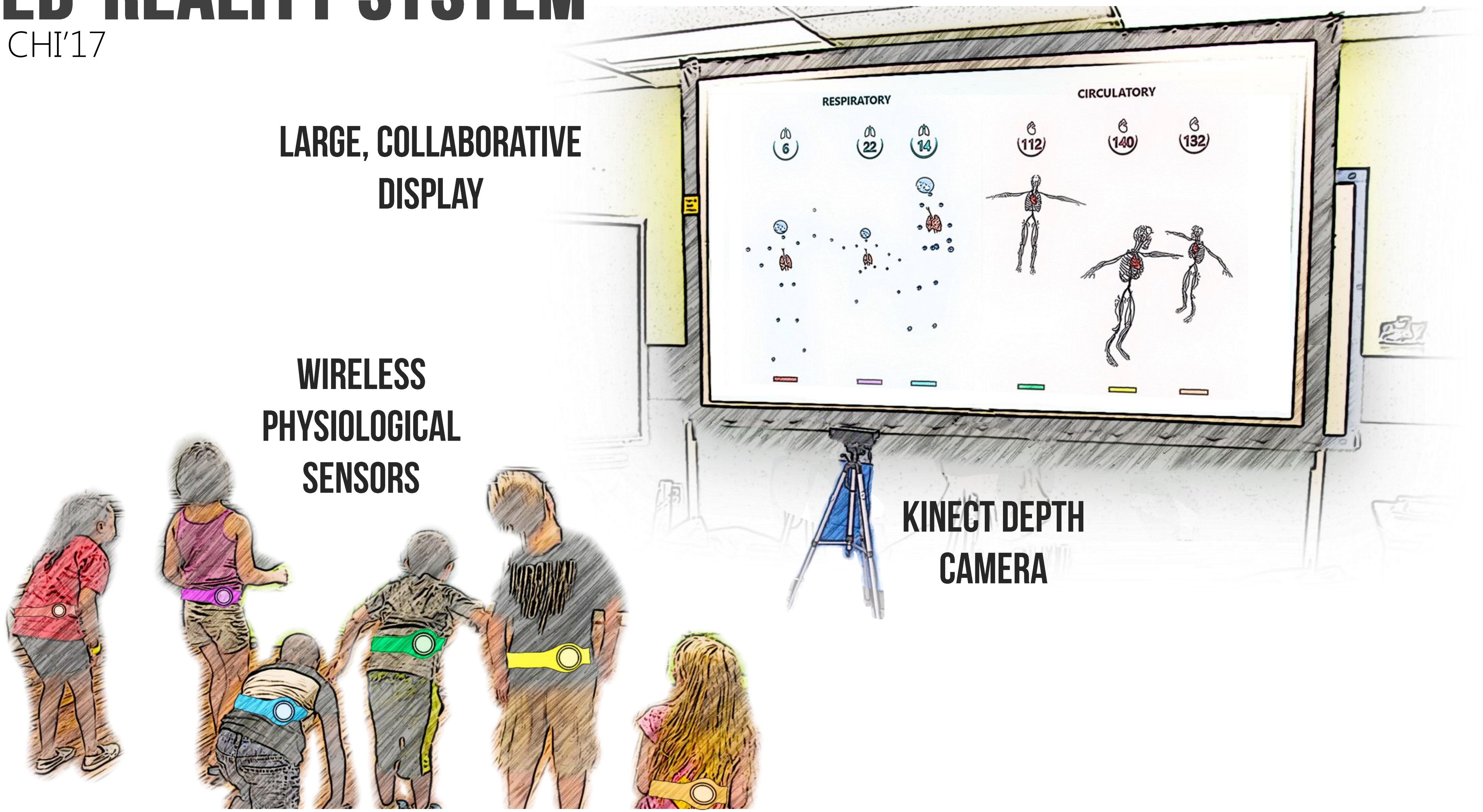
MIXED-REALITY SYSTEM

IDC'16, CHI'17

LARGE, COLLABORATIVE DISPLAY

WIRELESS PHYSIOLOGICAL SENSORS

KINECT DEPTH CAMERA



UNEXPECTED FINDING 2

How Does It Work?

THREAD 2: STEM EDUCATION

ENABLING NEW STEM LEARNING EXPERIENCES WITH WEARABLES

BODYVIS
[IDC'13, CHI'15 Honorable Mention, ICLS'16, IDC'16, CHI'17]

MAKERWEAR
[IDC'15, CHI'16 Best Poster, CHI'17 Best Paper]

THREAD 2: STEM EDUCATION

ENABLING NEW STEM LEARNING EXPERIENCES WITH WEARABLES

MAKERWEAR
[IDC'15, CHI'16 Best Poster, CHI'17 Best Paper]

How can we...
enable young children to build their own interactive wearables?

ENGAGING YOUNG CHILDREN IN WEARABLE DESIGN

MAKERWEAR TEAM

PROFESSORS

Jon Froehlich

Tamara Clegg

GRAD STUDENTS

Majeed Kazemitabaar

Liang He

UNDERGRADUATE STUDENTS

Jason McPeak

Katie Wang

Alex Jiao

Thomas Outing

Tony Cheng

HIGH SCHOOL STUDENT

Chloe Aloimonos

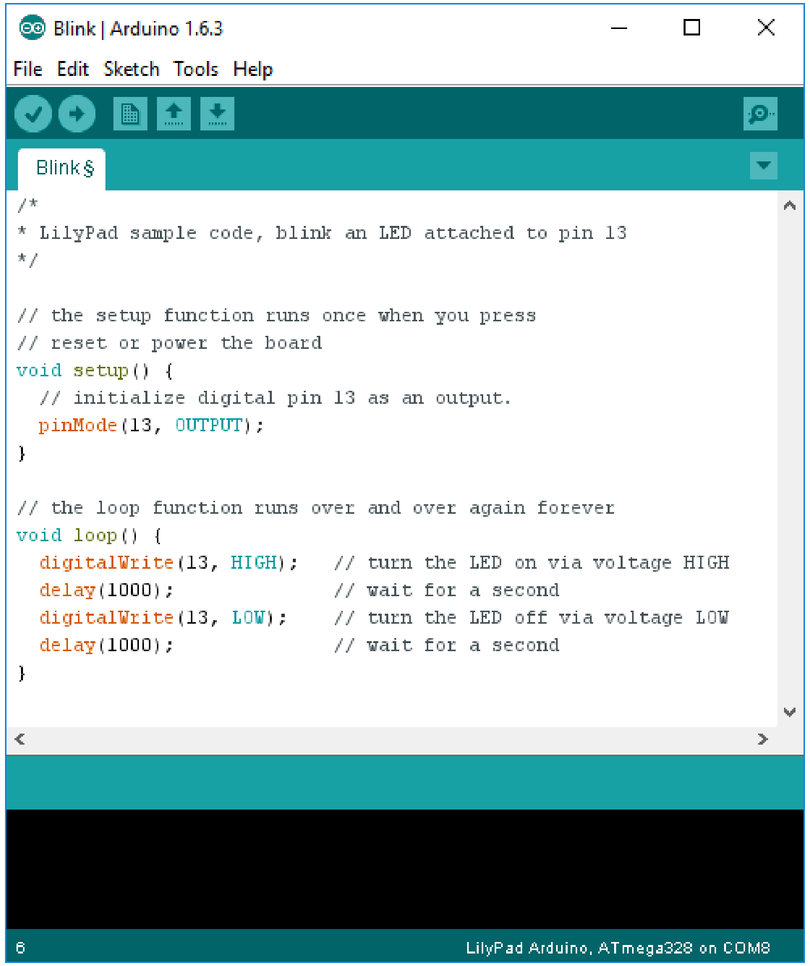

LILYPAD ARDUINO
LilyPad Arduino



See: Buechley & Hill, 2010; Kafai, Lee, *et al.,* 2014; Kafai, Fields, & Searle, 2014

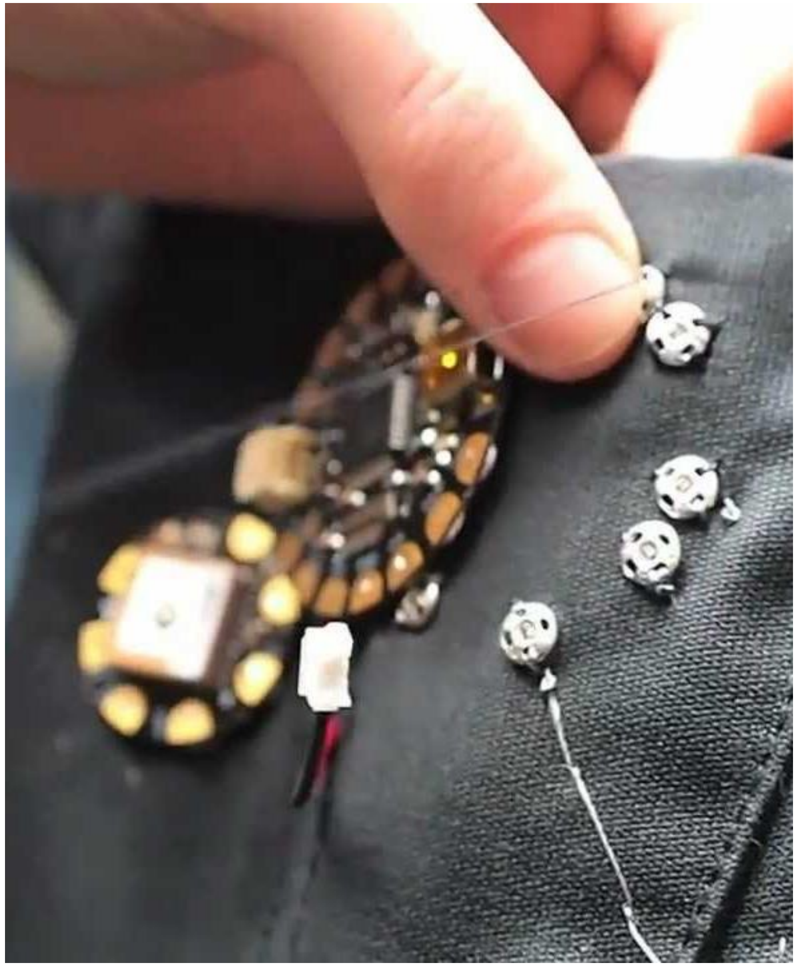
MAKERWEAR INTRODUCTION

CURRENT WEARABLE TOOLKITS

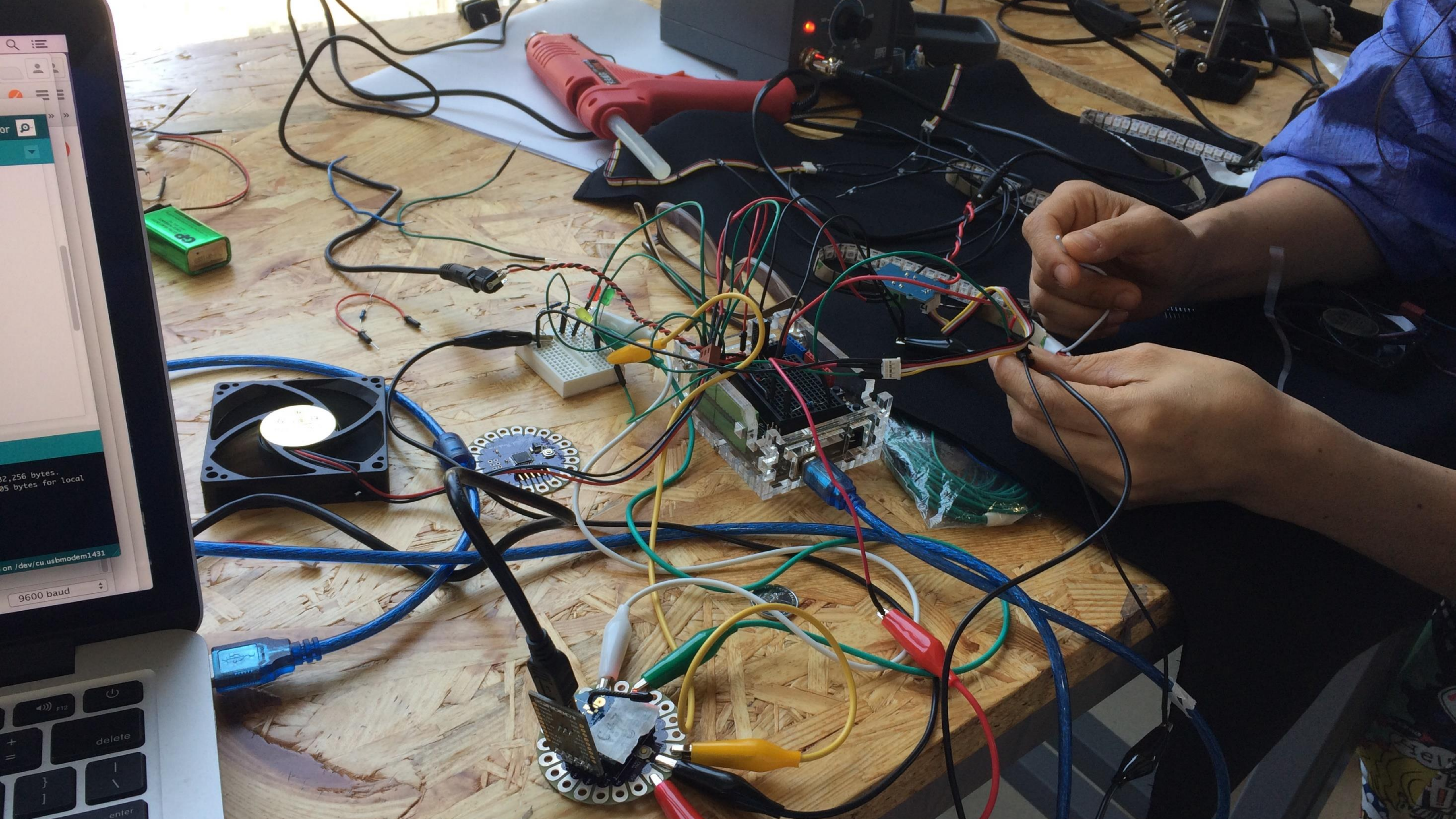


EMBEDDED PROGRAMMING

BASIC CIRCUIT & ELECTRONICS KNOWLEDGE



MANUAL SKILLS LIKE SEWING / SOLDERING


on /dev/cu.usbmodem1431
9600 baud
delete

Buechley, 2006; Davis, *et al.,* 2013; DuMont & Lee, 2015; Dunne *et al.,* 2015; Kafai *et al.,* 2014; Katterfeldt *et al.,* 2009; Ngai *et al.,* 2013; Richard & Kafai, 2015; Searle, *et al.,* 2014

MAKERWEAR INTRODUCTION

OVERARCHING RESEARCH QUESTIONS

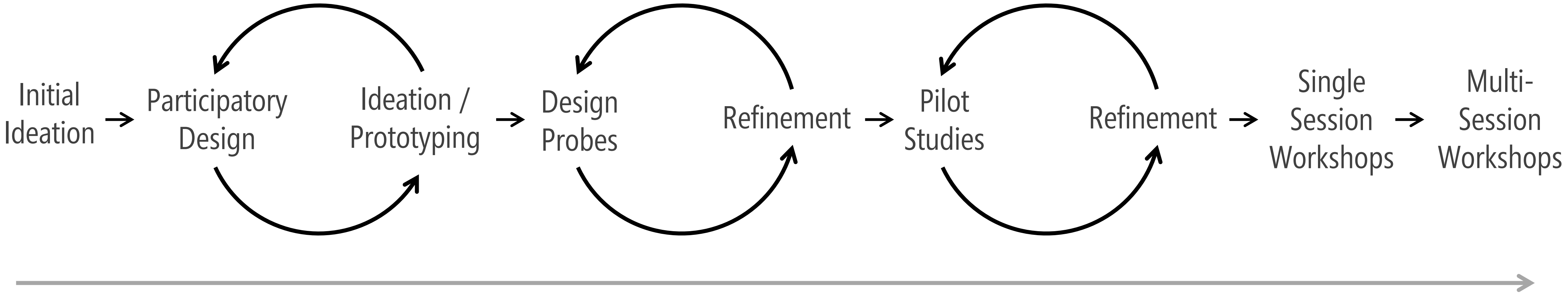
How can we enable young children (elementary age) to design & build their own interactive wearables?

What do children *want* to build and *how* can we support these goals?

How does working with our tools & techniques impact skill development & perceptions of STEM?

MAKERWEAR

DESIGN & EVALUATION PROCESS



TWO-YEAR ITERATIVE DESIGN PROCESS

PARTICIPATORY DESIGN

Cooperative Inquiry

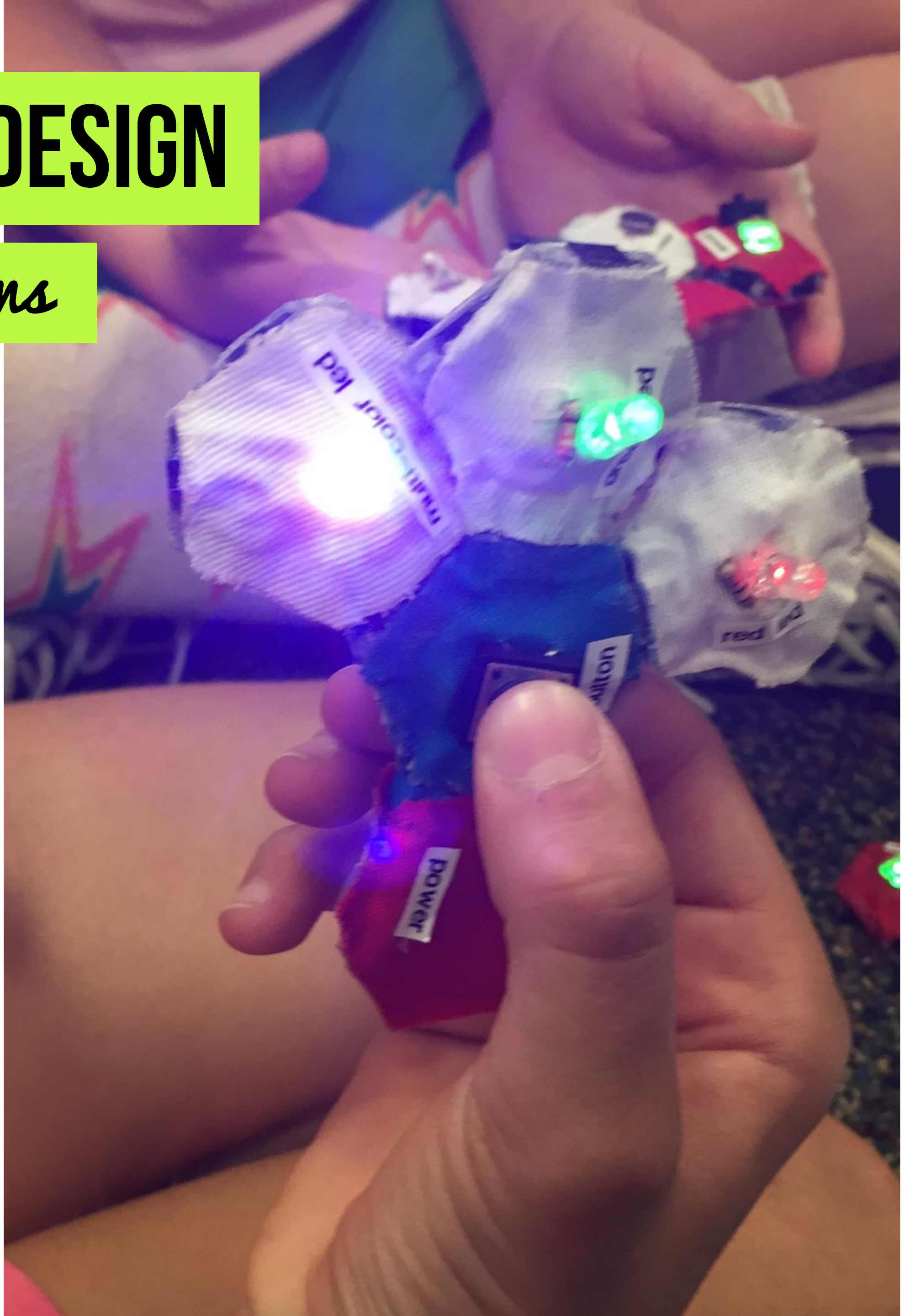
Cooperative Inquiry: Guha, Druin, & Fails, 2013

PARTICIPATORY DESIGN

Initial Sessions

PARTICIPATORY DESIGN

Follow-up Sessions



DESIGN PROBE

STEM Educators

WHAT DO CHILDREN WANT TO DESIGN WITH WEARABLES?

React to body movement & physiology (*e.g.,* heartrate)

Recognize gestures & physical actions (*e.g.,* recognize a jump)

Support social interaction (*e.g.,* vibrate when friend nearby)

Augment play experiences (*e.g.,* freeze tag)

Respond to environment (*e.g.,* increase visibility at night)

MAKERWEAR PARTICIPATORY DESIGN

WHAT DO CHILDREN WANT TO DESIGN WITH WEARABLES?

React to body movement & physiology

Recognize gestures & physical actions

Support social interaction

Augment play experiences

Respond to environment

These are the **key things** that any wearable toolkit for children should support


THE MAKERWEAR SYSTEM
https://github.com/MakerWear


Light
Light
Light
Vibration

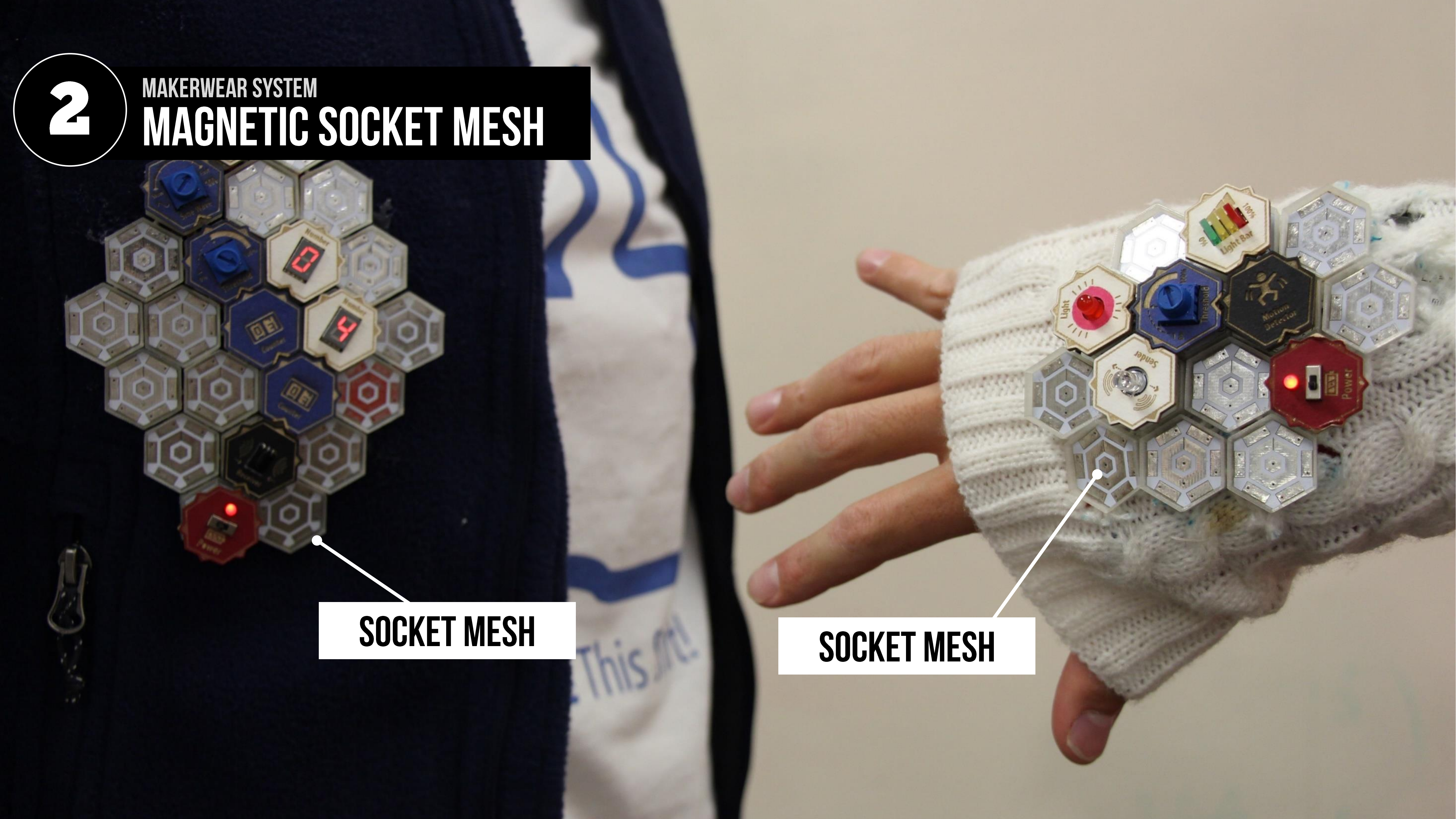
1 MAKERWEAR SYSTEM

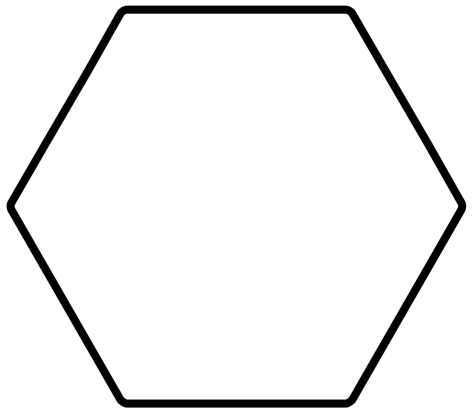
TANGIBLE MODULES

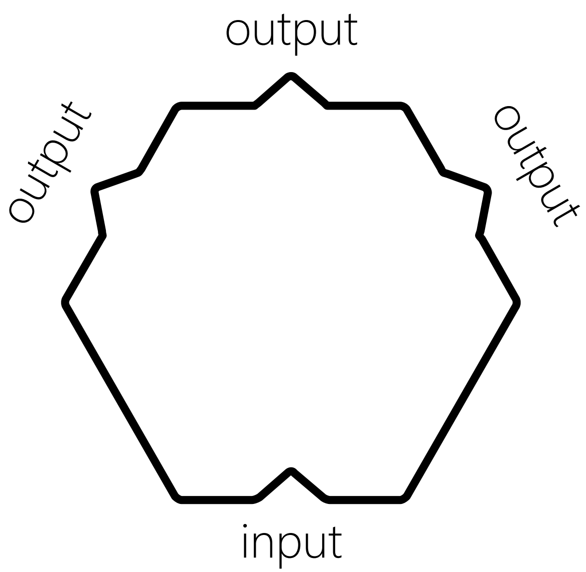
2

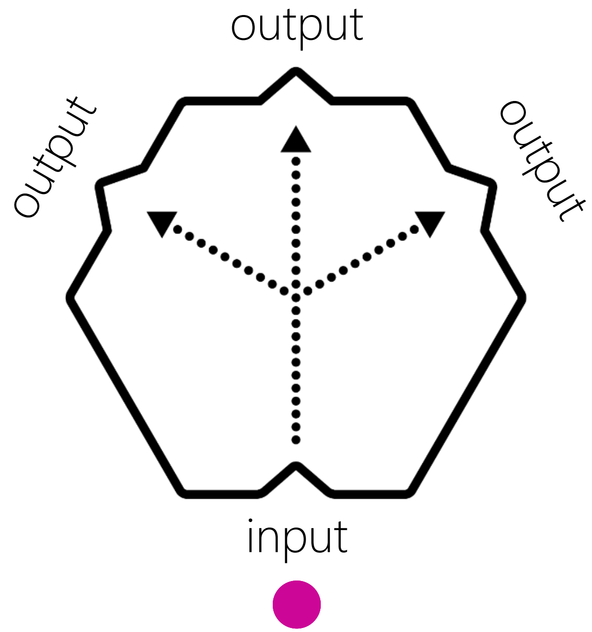
MAKERWEAR SYSTEM

MAGNETIC SOCKET MESH

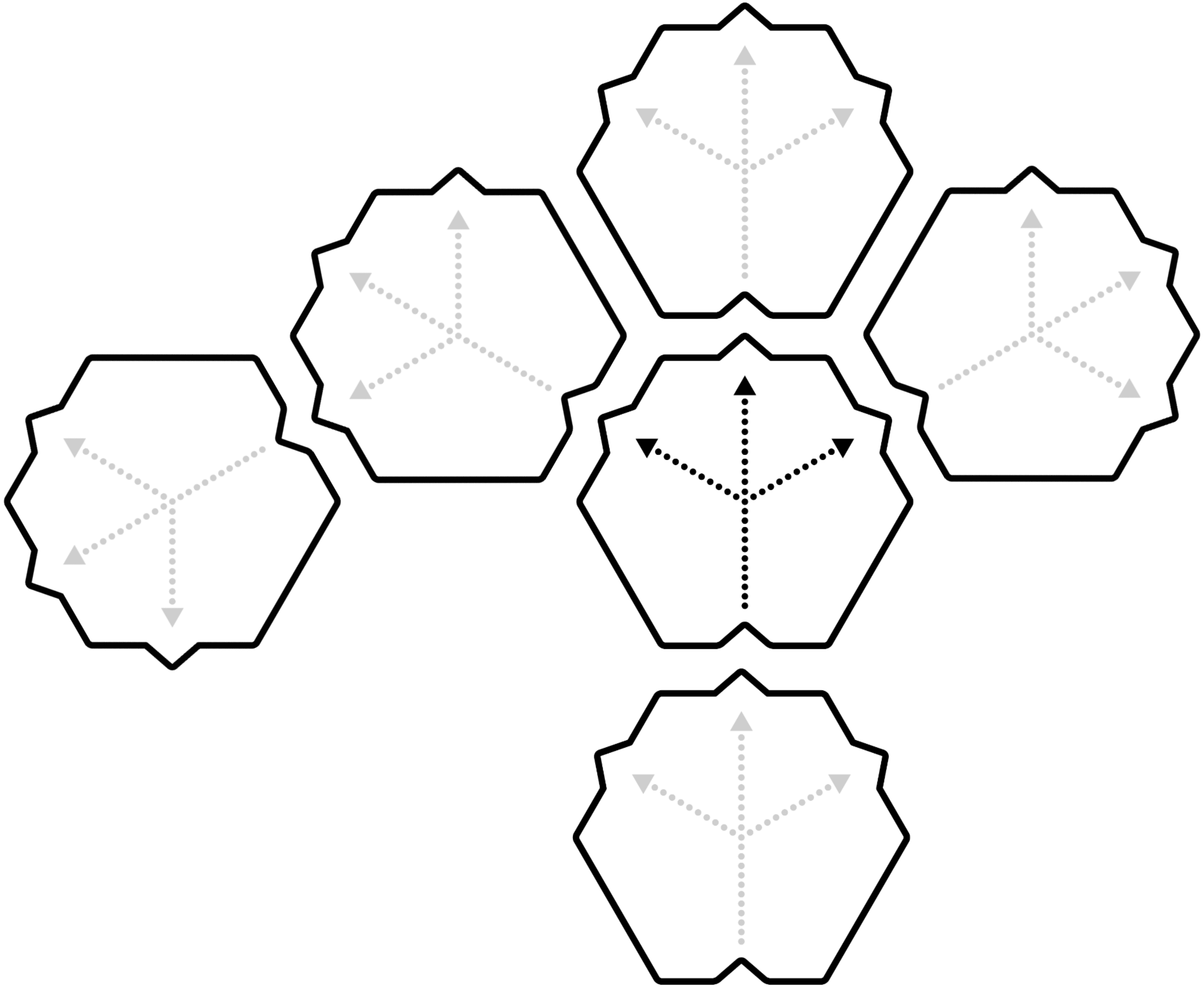





output
output
output
input

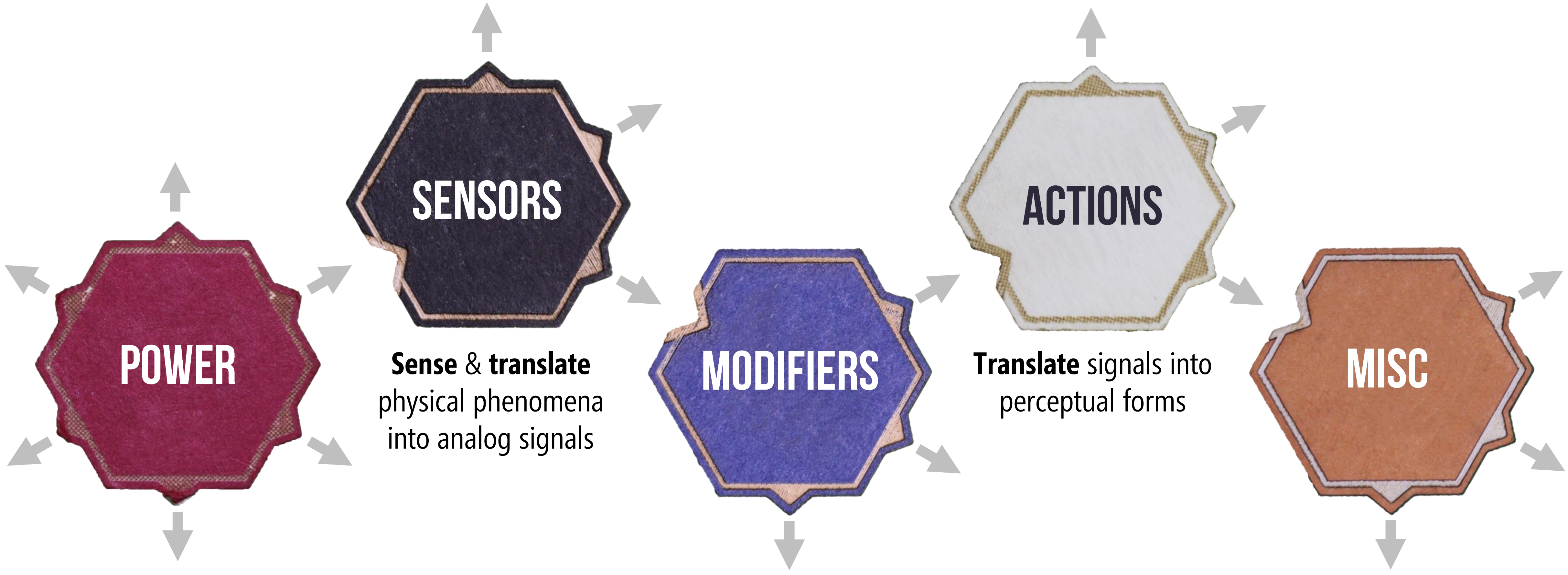


output
output
output
input



MAKERWEAR SYSTEM

5 MODULE TYPES



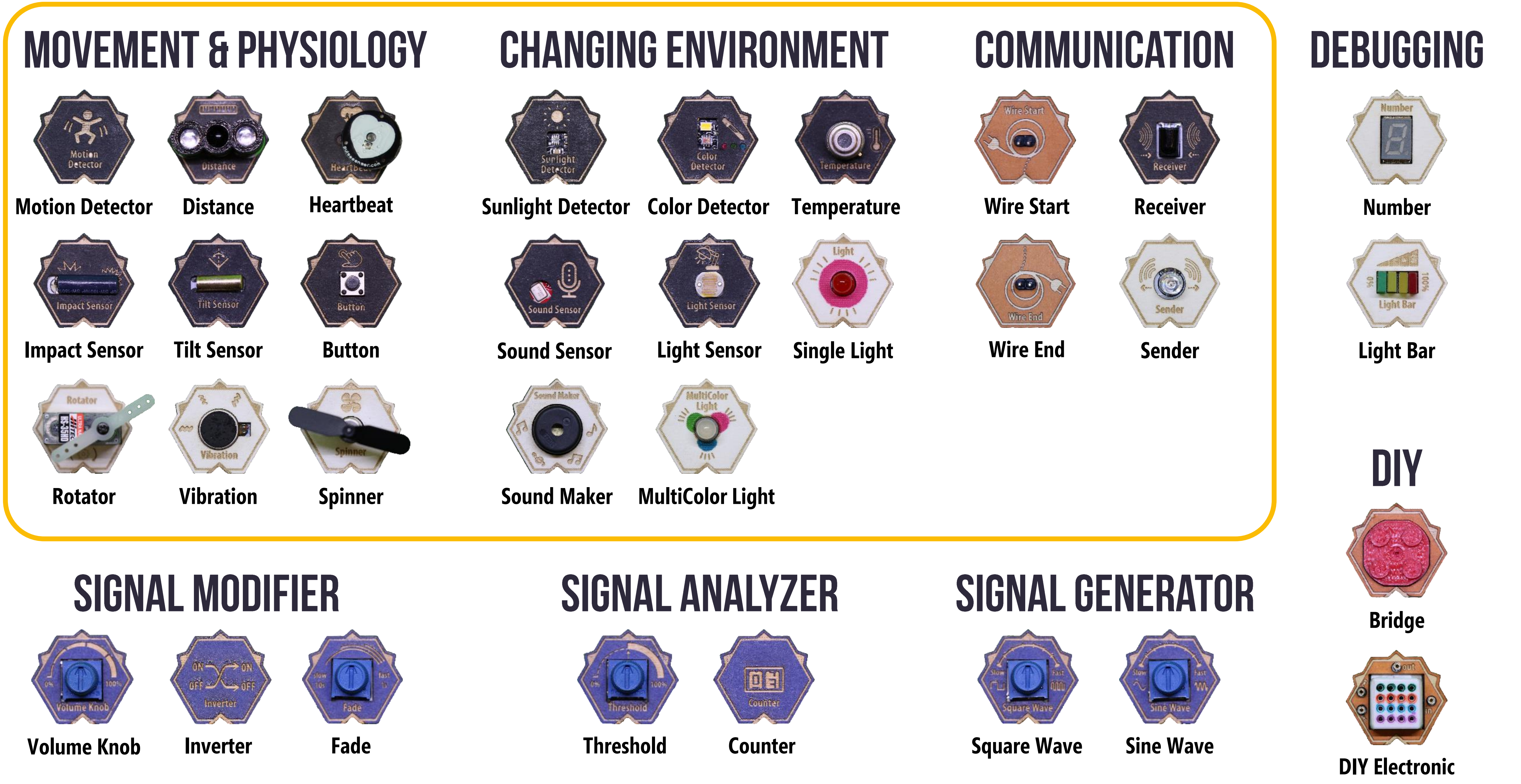
Provides **power** to all connected modules

Transform signals into other types of signals

Miscellaneous
(*e.g.,* DIY module)

MAKERWEAR SYSTEM

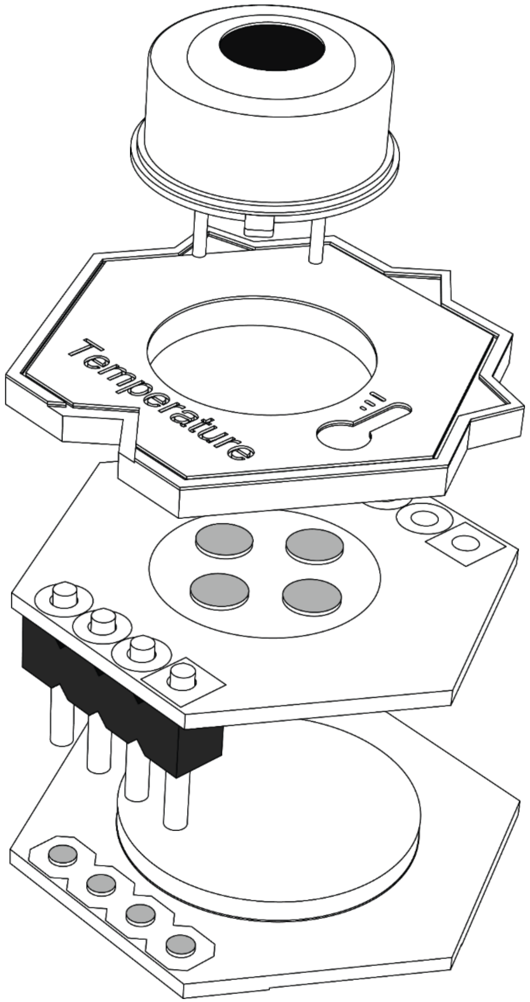
MODULE LIBRARY: 33 MODULES


MOVEMENT & PHYSIOLOGY
Motion Detector
Distance
Heartbeat
Impact Sensor
Tilt Sensor
Button
Rotator
Vibration
Spinner
CHANGING ENVIRONMENT
Sunlight Detector
Color Detector
Temperature
Sound Sensor
Light Sensor
Single Light
Sound Maker
MultiColor Light
COMMUNICATION
Wire Start
Receiver
Wire End
Sender
DEBUGGING
Number
Light Bar
DIY
Bridge
DIY Electronic
SIGNAL MODIFIER
Volume Knob
Inverter
Fade
SIGNAL ANALYZER
Threshold
Counter
SIGNAL GENERATOR
Square Wave
Sine Wave

MAKERWEAR SYSTEM

MODULE EXPLODED VIEW

Temperature Sensor

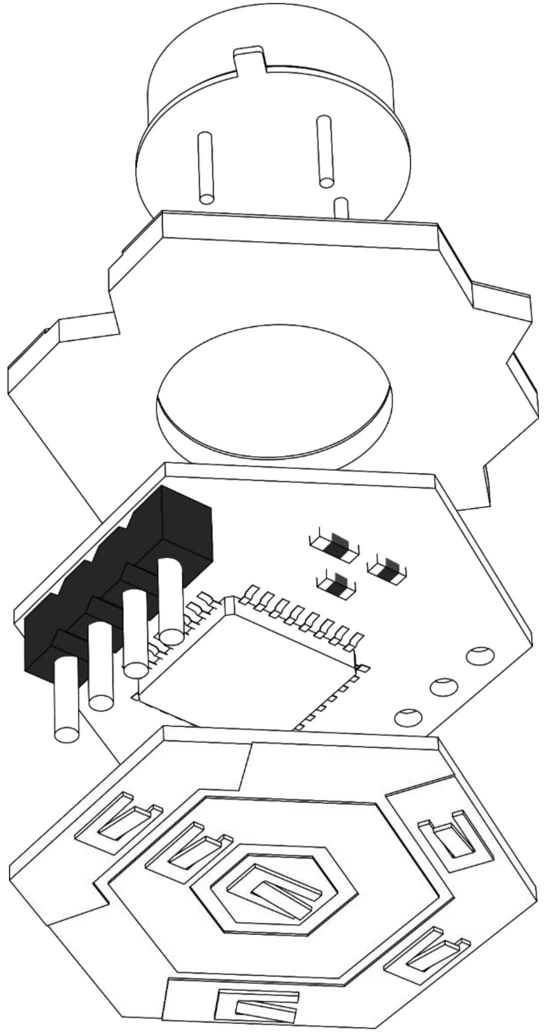


LAYER 1
Exposed electronic component

LAYER 2
Laser cut module cover

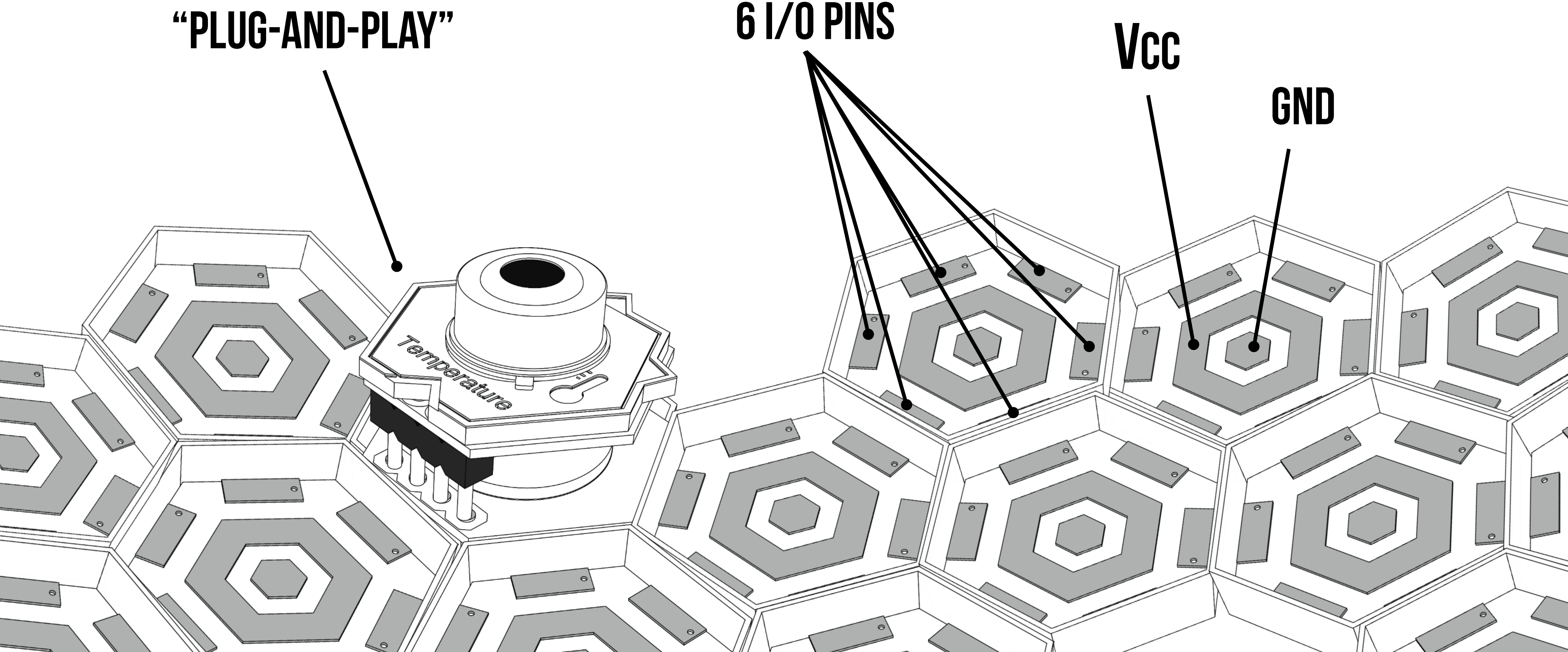
LAYER 3
Custom PCB with embedded microcontroller & SMD components

LAYER 4
Custom PCB with neodymium magnet & contact spring for socket connection



MAKERWEAR SYSTEM

SOCKET MESH



MAKERWEAR SYSTEM

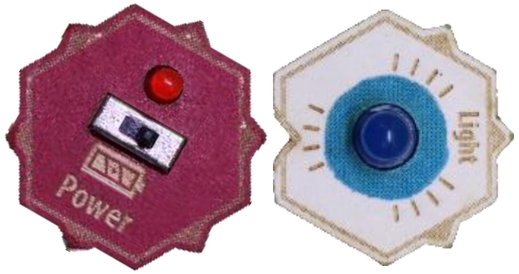
TWO TYPES OF SOCKET MESHES

The number of sockets per mesh ranges from 14-23

1. SEWN INTO CLOTHES

2. FABRIC PATCH


Power


Power
Light


Power
Motion Detector
Light

MAKERWEAR EXAMPLES

"MOTION-REACTIVE CLOTHES"

Motion-reactive clothes!

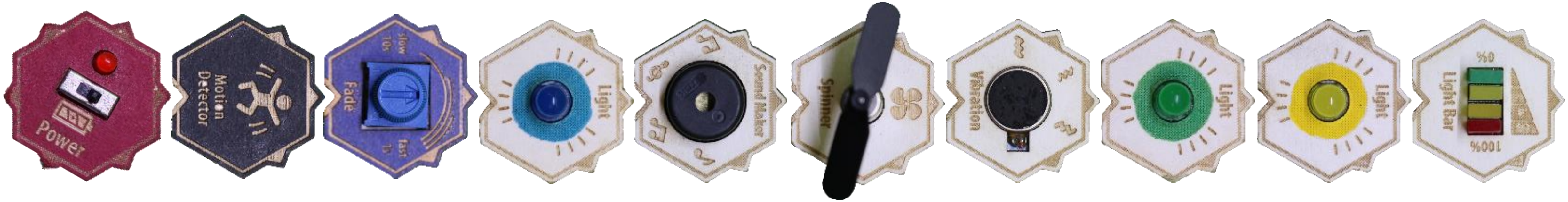
MAKERWEAR EXAMPLES

"MOTION-REACTIVE CLOTHES"

Now with fade effect

MAKERWEAR EXAMPLES

“MOTION-REACTIVE CLOTHES”



MAKERWEAR EXAMPLES

“MOTION-REACTIVE CLOTHES”

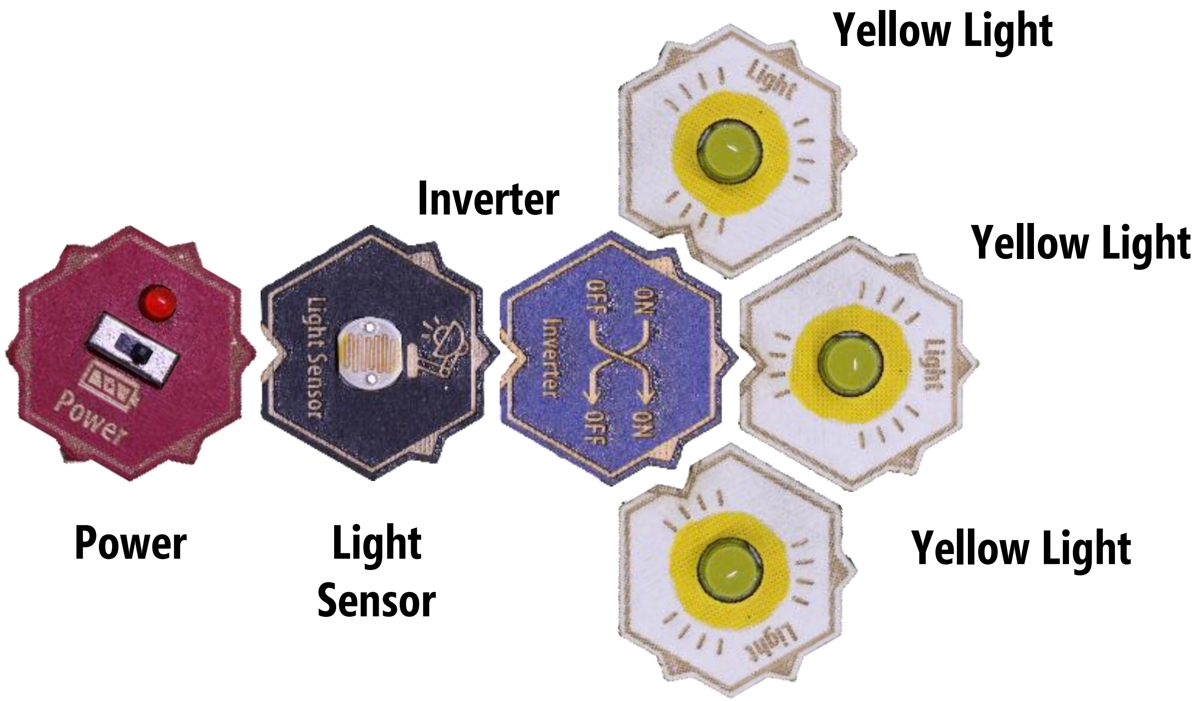
MAKERWEAR EXAMPLES

“MOTION-REACTIVE CLOTHES”

We can create a diverse set of designs tangibly

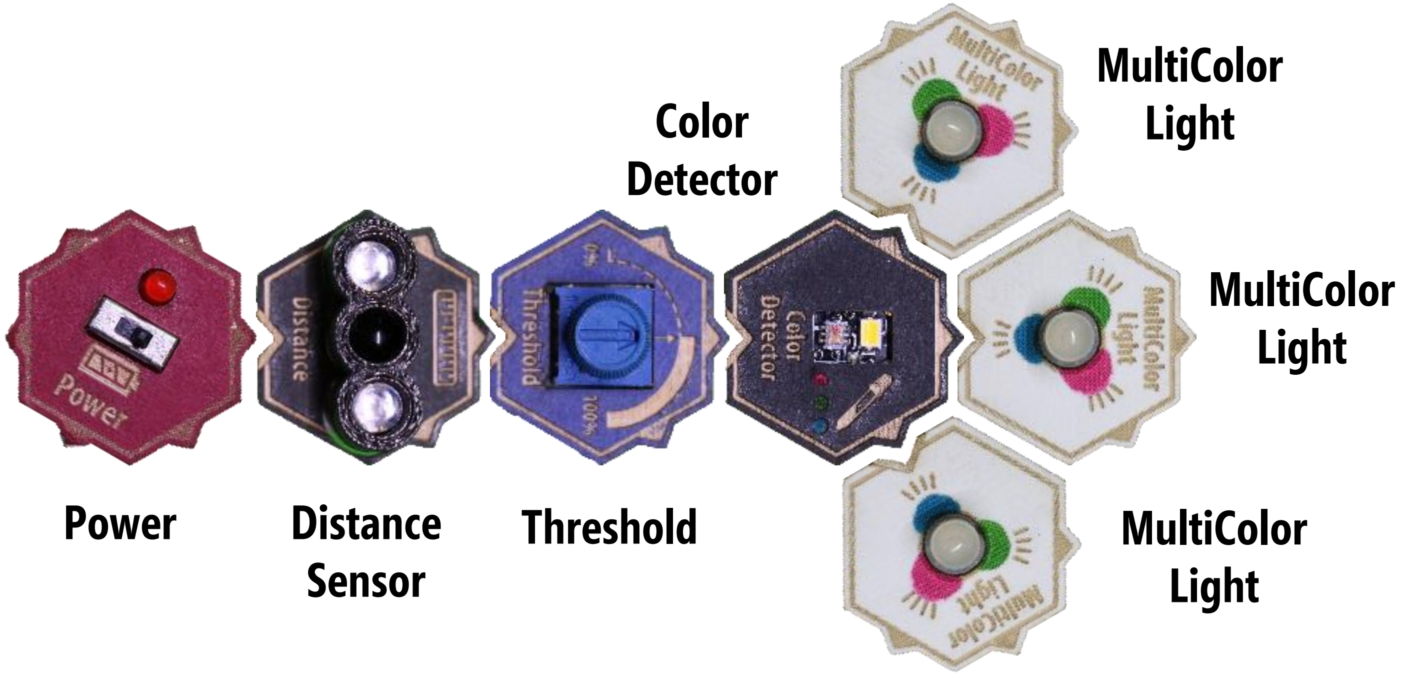
MAKERWEAR EXAMPLES

"AUTO-HEADLAMP HAT"



MAKERWEAR EXAMPLES

“CHAMELEON CLOTHES”



MAKERWEAR EXAMPLES

“LASER TAG ARMBAND”

When button pressed, shoots “laser” (IR beam) and turns on blue LED

When “hit” by IR beam, turns red

MAKERWEAR EXAMPLES

“LASER TAG ARMBAND”

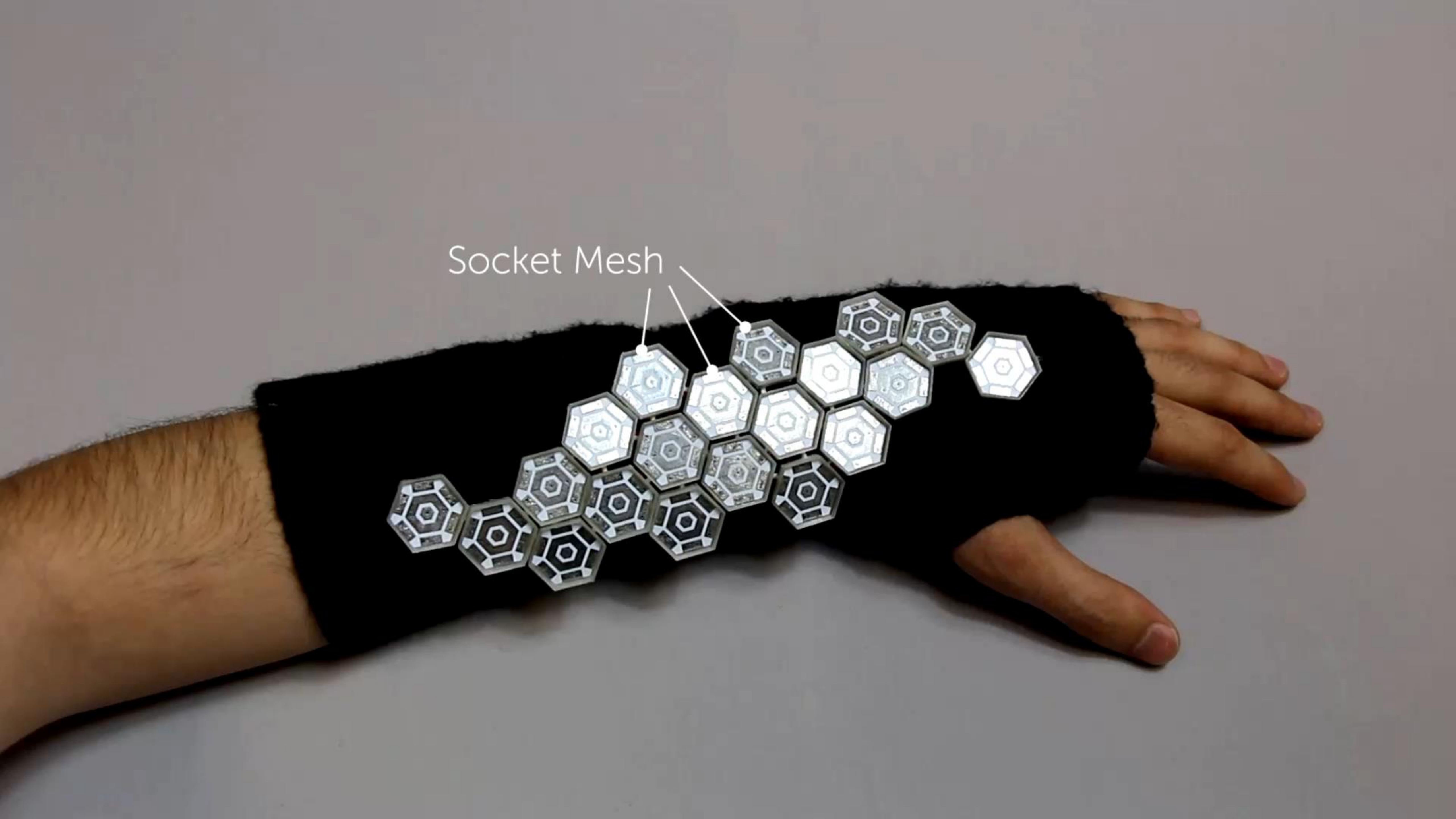
Tracks hit count

Sets max hit count level

When button pressed, shoots “laser” (IR beam) and turns on blue LED

When “hit” by IR beam, turns red

Flashes lights & plays sound when max hit count level reached


Socket Mesh


Light

MAKERWEAR EVALUATION

WORKSHOP-BASED EVALUATIONS

32 children (16 female; ages 5-12; *avg*=8.3)

Two single-session workshops (*N*=13)

Three four-session workshops (*N*=19)

Workshops common method for e-textile studies. *E.g.,* Buechley *et al.,* 2006; Katterfeldt *et al.,* 2009; Searle *et al.,* 2014; Richard & Kafai, 2015;

WORKSHOP SESSIONS & DEMOGRAPHICS

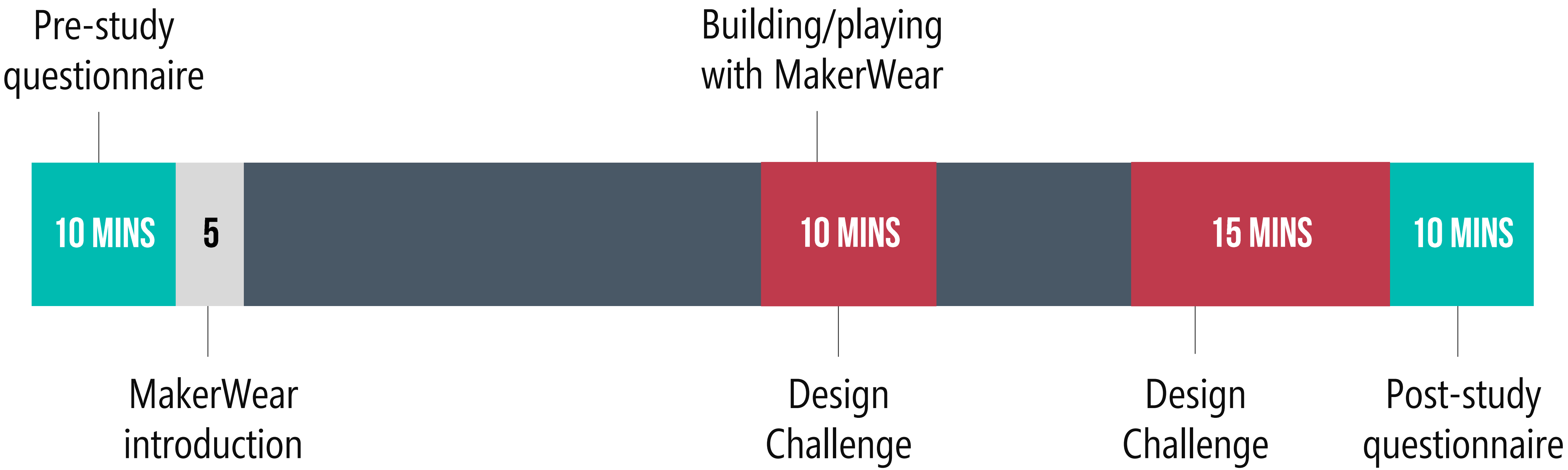
	Group	Ages (Avg)	N (female)
SINGLE SESSION	1	5-7 (6.0)	5 (5)
	2	8-12 (9.9)	8 (3)
MULTI-SESSION	1	5-7 (6.3)	7 (3)
	2	8-9 (8.8)	6 (1)
	3	8-12 (10.2)	6 (4)
	Total	**5-12 (8.3)**	**32 (16)**

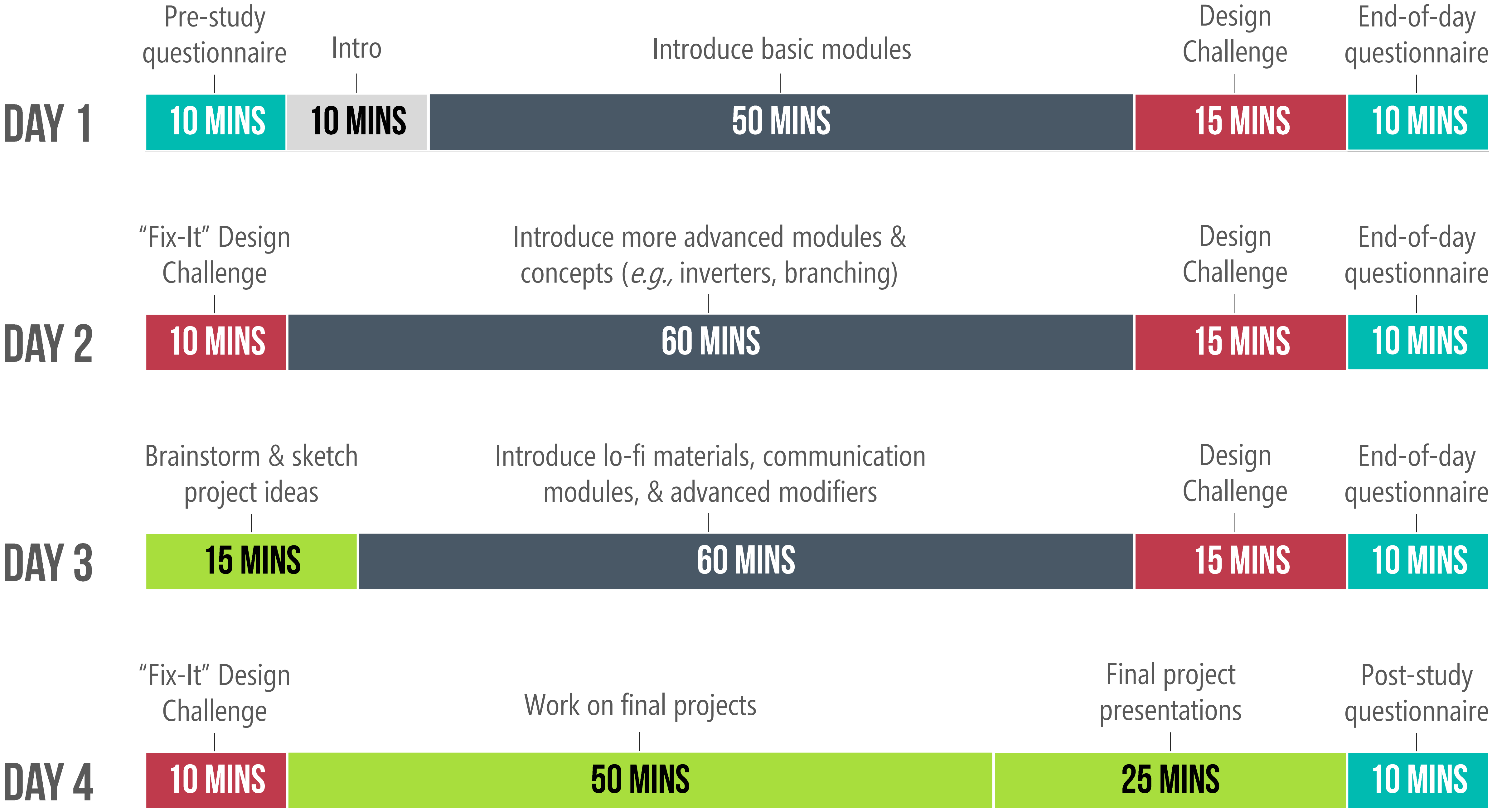
WORKSHOP SESSIONS & DEMOGRAPHICS

	Group	Ages (Avg)	N (female)	Uses computer at least a few times a week	Has used a graphical programming system (*e.g.*, Scratch)	Has used an electronic kit (*e.g.*, Snap Circuits, Lego Mindstorms, littleBits)
SINGLE SESSION	1	5-7 (6.0)	5 (5)	100%	40%	20%
	2	8-12 (9.9)	8 (3)	88%	38%	50%
MULTI-SESSION	1	5-7 (6.3)	7 (3)	100%	57%	57%
	2	8-9 (8.8)	6 (1)	83%	50%	66%
	3	8-12 (10.2)	6 (4)	83%	83%	66%
	Total	**5-12 (8.3)**	**32 (16)**	**91%**	**53%**	**53%**

MAKERWEAR EVALUATION

SINGLE-SESSIONS WORKSHOP PROCEDURE




DAY 1
Pre-study questionnaire
10 MINS
Intro
10 MINS
Introduce basic modules
50 MINS
Design Challenge
15 MINS
End-of-day questionnaire
10 MINS
DAY 2
"Fix-It" Design Challenge
10 MINS
Introduce more advanced modules & concepts (e.g., inverters, branching)
60 MINS
Design Challenge
15 MINS
End-of-day questionnaire
10 MINS
DAY 3
Brainstorm & sketch project ideas
15 MINS
Introduce lo-fi materials, communication modules, & advanced modifiers
60 MINS
Design Challenge
15 MINS
End-of-day questionnaire
10 MINS
DAY 4
"Fix-It" Design Challenge
10 MINS
Work on final projects
50 MINS
Final project presentations
25 MINS
Post-study questionnaire
10 MINS

DATA & ANALYSIS

Session video

Design challenge performance (Radar *et al.*, 1997)

End-user creations (Duncan *et al.*, 2014; Hansen *et al.*, 2015)

Artifact-based interviews (Brennan & Resnick, 2012)

Pre & post-study questionnaires

MAKERWEAR FINDINGS

MAKERWEAR FINDINGS

OVERALL

- Highly engaged in making
- Wide variety of designs
- Applied computational thinking

MAKERWEAR FINDINGS

MakerWear understanding & CT

What did children make?

Some unexpected things

MAKERWEAR FINDINGS

INPUT/OUTPUT & SEQUENCING

EXAMPLE FIX-IT DESIGN CHALLENGES

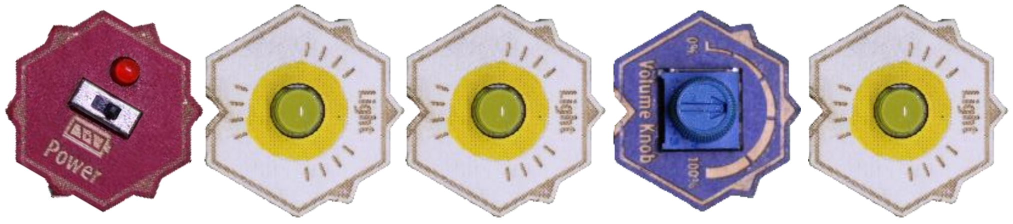
Fix this so the light responds to the sensor

Power | Light Sensor | MultiColor Light

Fix this so the lightbar responds to the sensor

Power | Light Bar | Distance

Fix this so all light levels are controlled by the volume knob

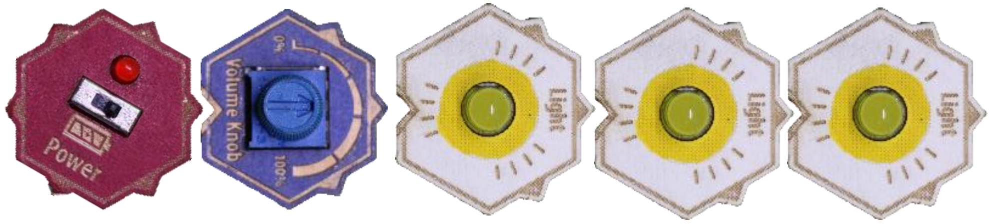


Power | Yellow Light | Yellow Light | Volume Knob | Yellow Light

EXAMPLE SOLUTIONS

Power | Light Sensor | MultiColor Light

Power | Distance | Light Bar



Power | Volume Knob | Yellow Light | Yellow Light | Yellow Light

MAKERWEAR FINDINGS

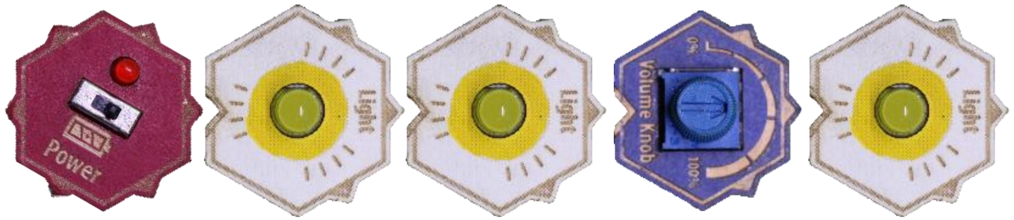
INPUT/OUTPUT & SEQUENCING

Youngest=6.3; Middle=8.8; Oldest=10.2 years old

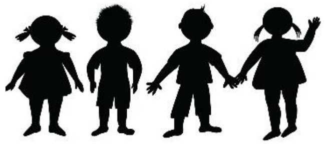
EXAMPLE FIX-IT DESIGN CHALLENGES

Power Light Sensor MultiColor Light

Power Light Bar Distance



Power Yellow Light Yellow Light Volume Knob Yellow Light



Youngest

81%

Middle

100%

Oldest

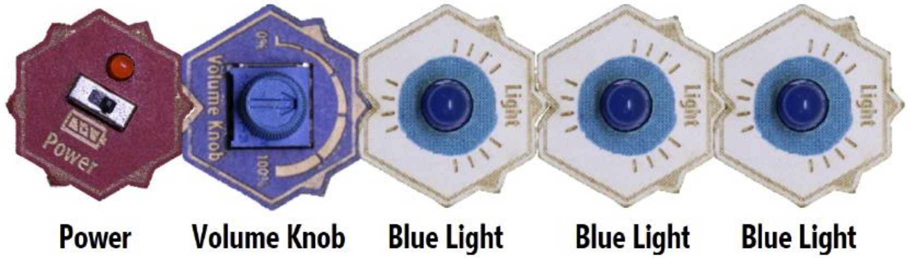
100%

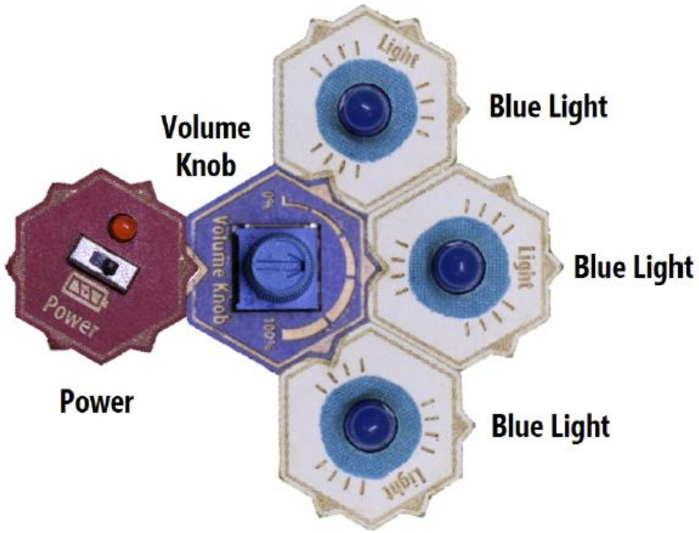
MAKERWEAR FINDINGS

BRANCHING

Youngest=6.3; Middle=8.8; Oldest=10.2 years old

Do these two designs behave differently?





Youngest	Middle	Oldest
43%	**100%**	**100%**

MAKERWEAR FINDINGS

PROGRESSIONS

Youngest=6.3; Middle=8.8; Oldest=10.2 years old

FIRST DAY	LAST DAY
47%	**77%**
Sequencing	Sequencing

FIRST DAY	LAST DAY
20%	**78%**
Conditional Logic	Conditional Logic

Middle & Oldest Groups Only

MAKERWEAR FINDINGS

FINAL PROJECTS


Omar, Age 6

Justin, Age 8


Tyrese, Age 5


LeShawn, Age 6

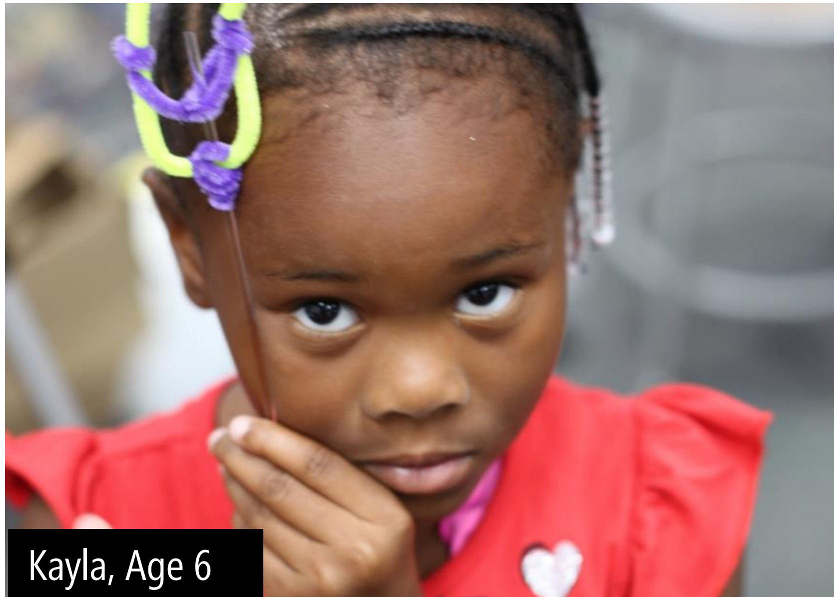

Sarah, Age 9


Keisha, Age 6


Austin, Age 9


Amelia, Age 10


Tina, Age 8


Kayla, Age 6

MAKERWEAR FINDINGS

AGE-RELATED DIFFERENCES IN FINAL PROJECTS

Youngest=6.3; Middle=8.8; Oldest=10.2 years old

Error bars are standard error

MAKERWEAR FINAL PROJECTS

WHAT DID CHILDREN MAKE?

SPORTS/FITNESS

38%

ROLE PLAY

31%

SOCIO-DRAMATIC PLAY

19%

OTHER

13%

WHAT SENSORS DID THEY USE?

Temperature

Motion Detector

Distance

Volume Knob

Sunlight Detector

Light Sensor

Wire Start

Receiver

Impact Sensor

Tilt Sensor

Button

Color Detector

Sound Sensor


Heartbeat

Wire End

Sender

MOVEMENT
33%

MANUAL INPUT
24%

ENVIRONMENT
19%

PHYSIOLOGY
14%

SOCIAL
10%

I want to highlight a few projects that demonstrate the **breadth of designs**, the span of **technical sophistication**, & illustrate the aforementioned **themes**

MAKERWEAR FINAL PROJECTS

WHAT DID CHILDREN MAKE?

SPORTS/FITNESS

38%

ROLE PLAY

31%

SOCIO-DRAMATIC PLAY

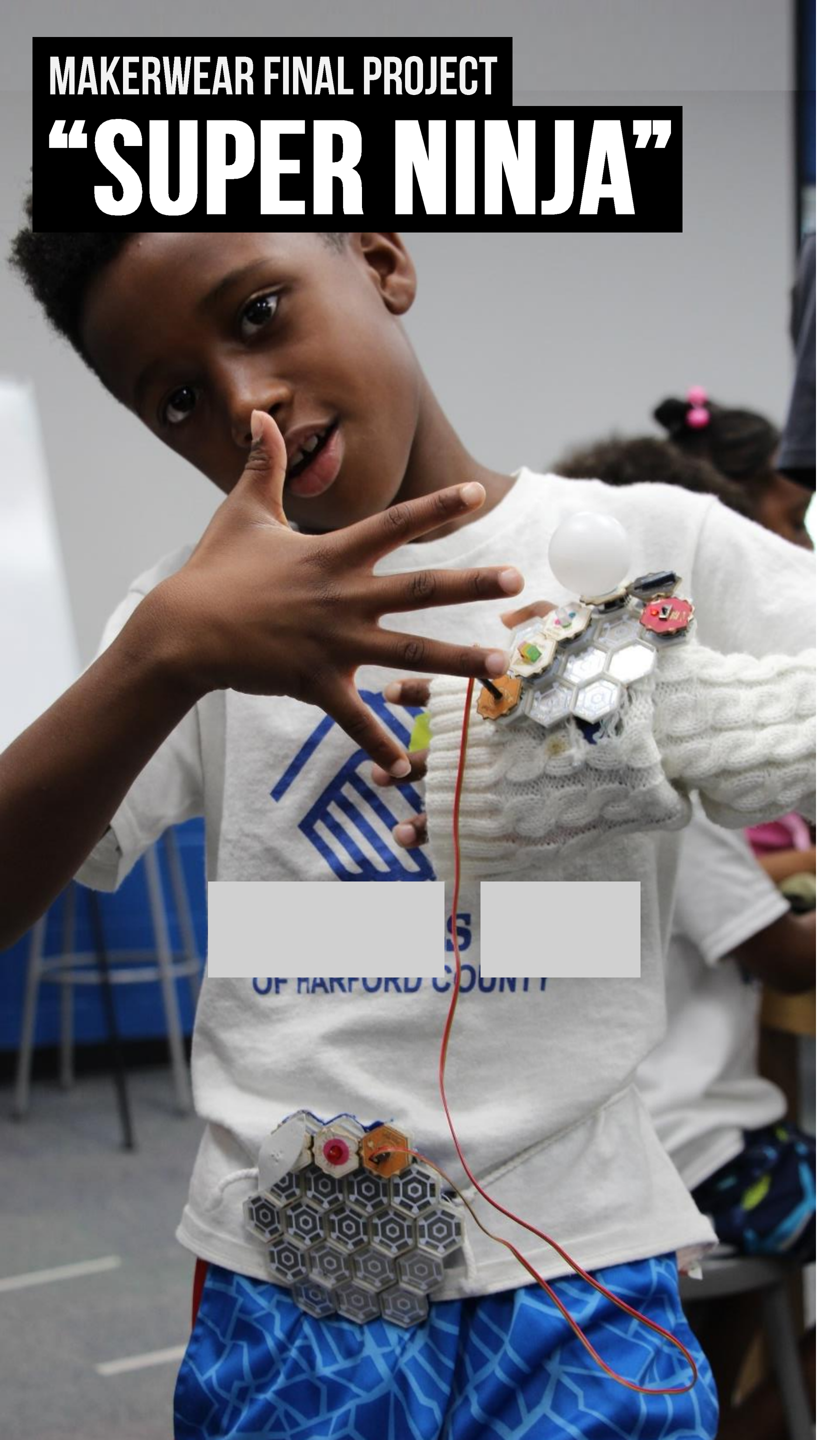
19%

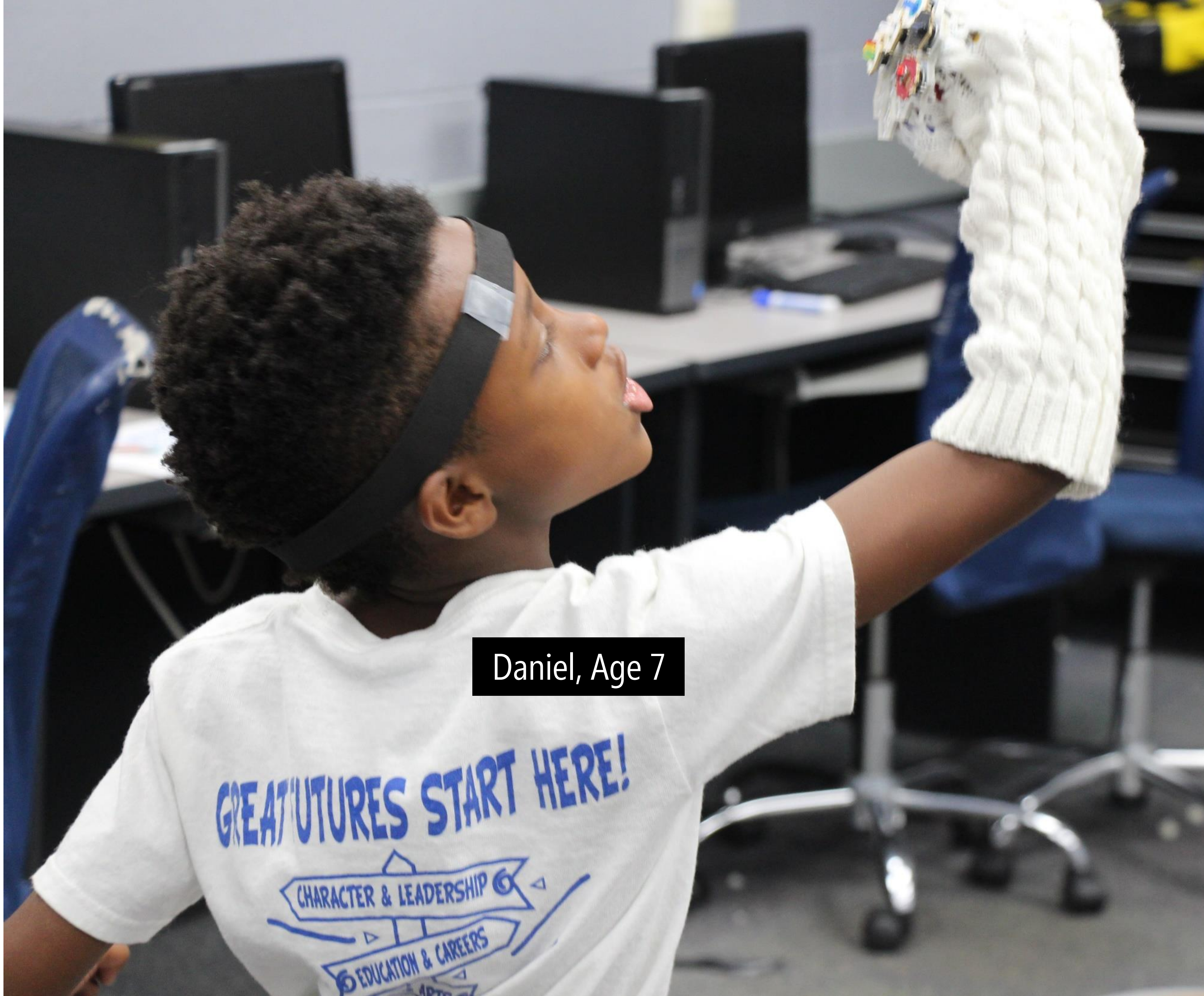
OTHER

13%

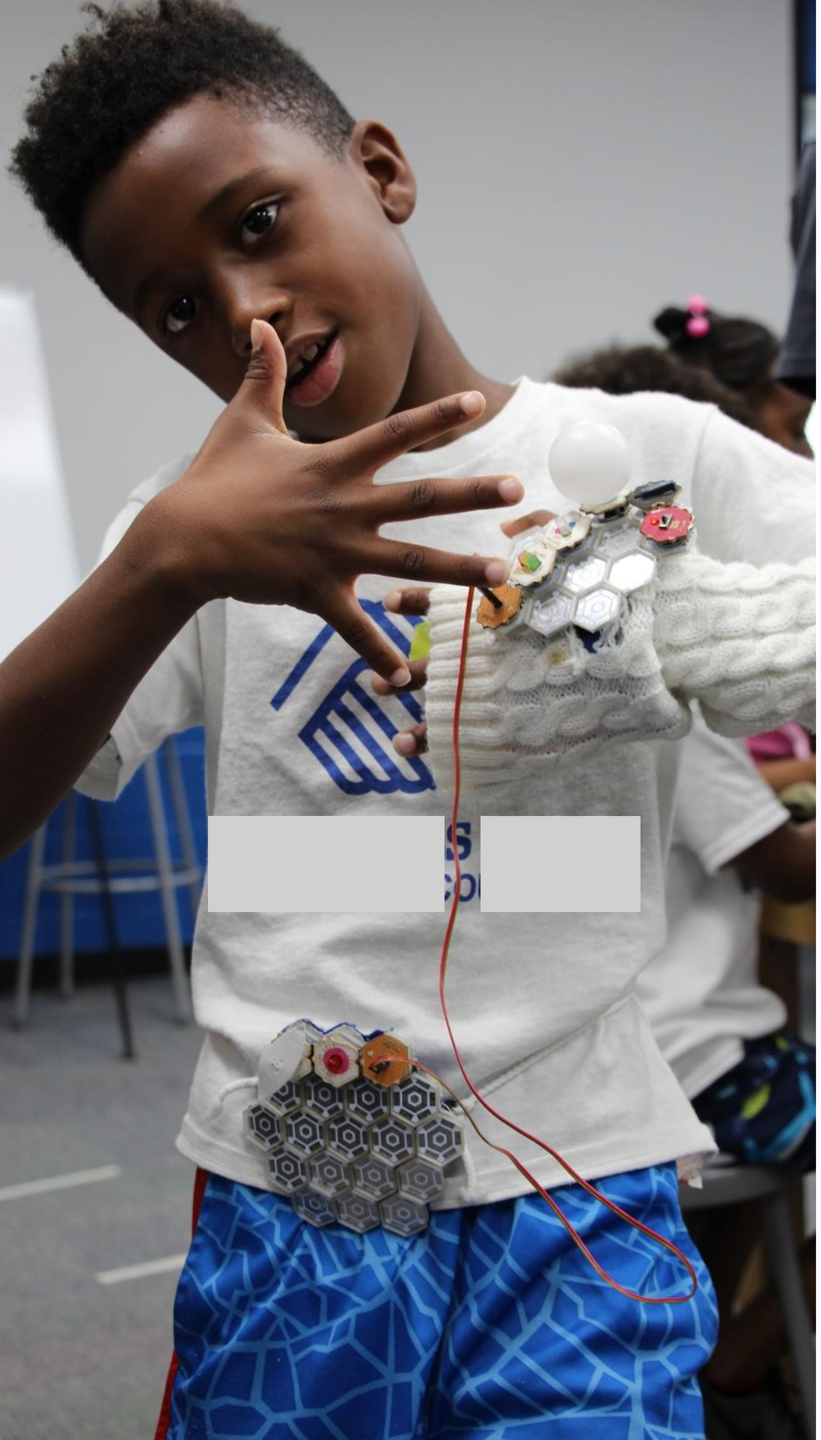
MAKERWEAR FINAL PROJECT

“SUPER NINJA”





Daniel, Age 7

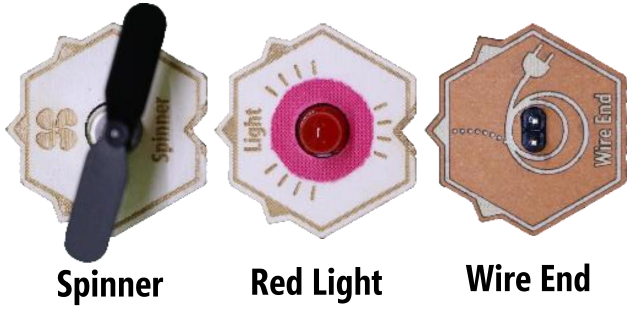


SUPER NINJA

Maker: Daniel, Age 7
9 modules: 5 actions, 2 misc, 1 sensor
2 socket meshes
2 lo-fi pieces

"UPPER CUT" ARMBAND

"NINJA" BELT



MAKERWEAR FINAL PROJECTS

WHAT DID CHILDREN MAKE?

SPORTS/FITNESS

38%

ROLE PLAY

31%

SOCIO-DRAMATIC PLAY

19%

OTHER

13%

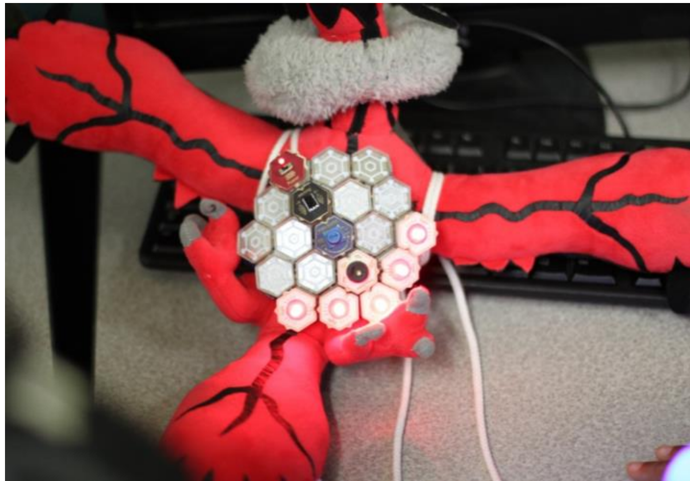

MAKERWEAR FINAL PROJECT
“MAGIC POKÉMON”
Austin, Age 9

MAGIC YVELTAL POKÉMON

Maker: Austin, Age 9
14 modules: 9 actions, 2 sensors, 1 modifier
2 socket meshes
3 lo-fi pieces + pokemon

VEST

POKÉMON DOLL



MAKERWEAR FINAL PROJECTS

WHAT DID CHILDREN MAKE?

SPORTS/FITNESS

38%

ROLE PLAY

31%

SOCIO-DRAMATIC PLAY

19%

OTHER

13%

MAKERWEAR FINAL PROJECT

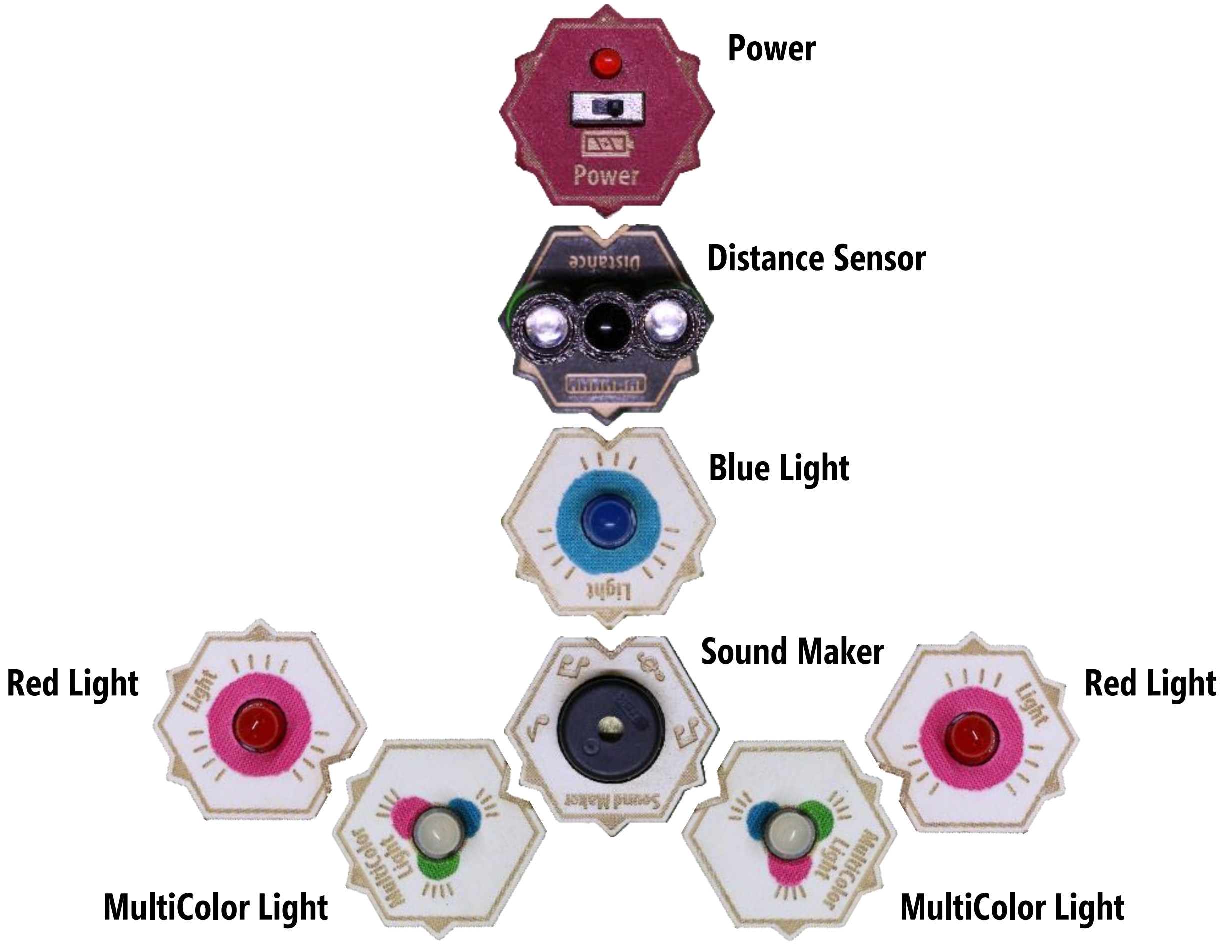
“SMART LACROSSE STICK”

Sarah, Age 9


BAD
AD'S
SUPERMAN
LOVES STEM
KEEP
GOING

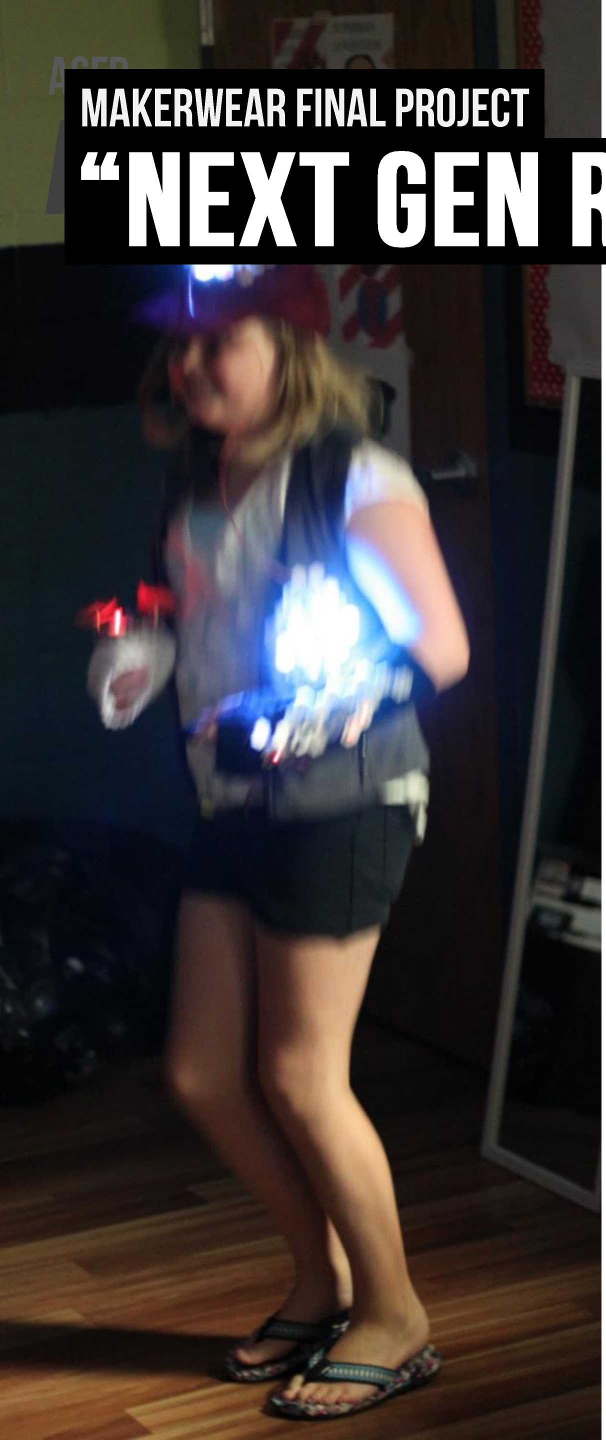
SMART LACROSSE STICK

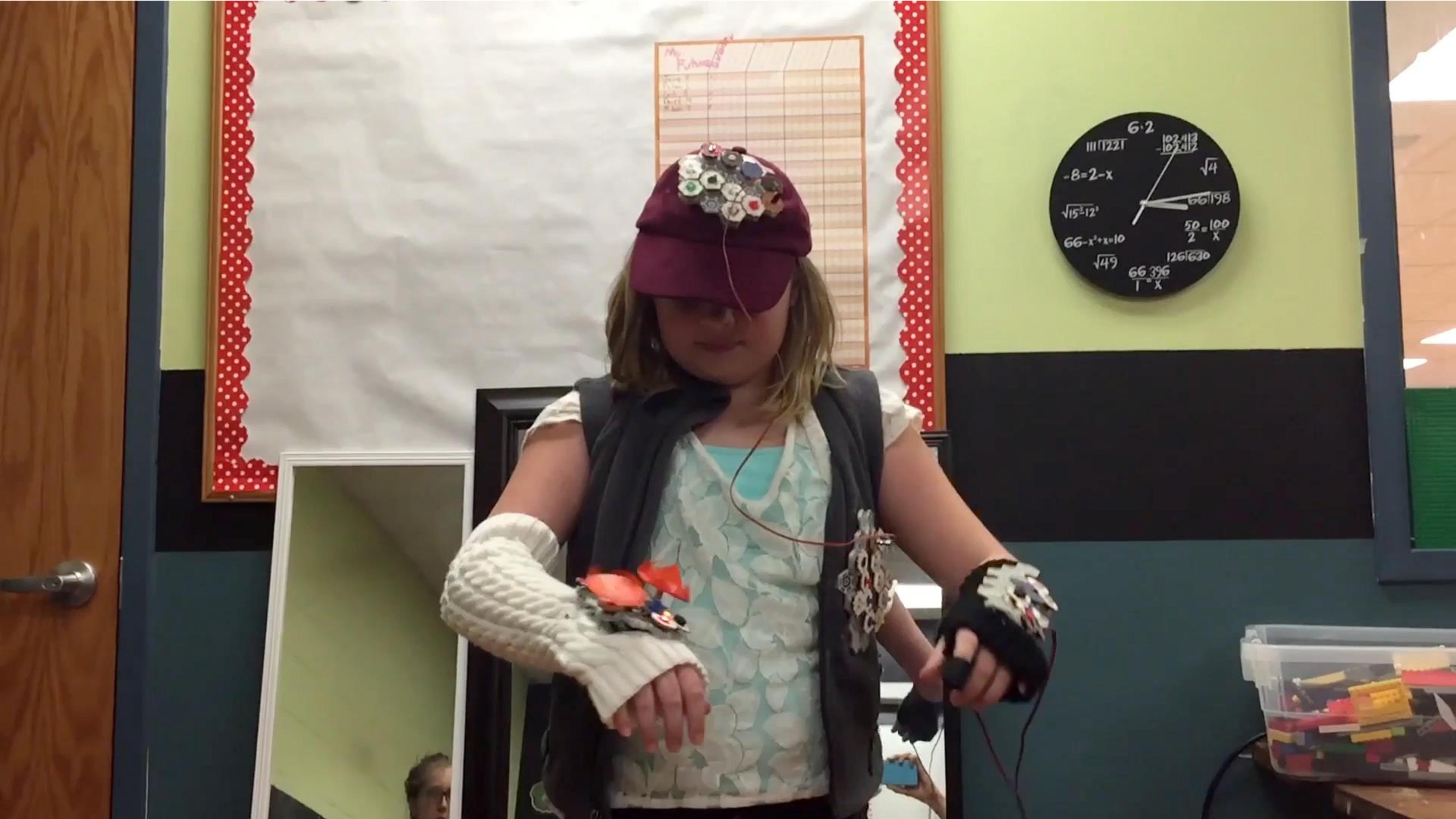
Maker: Sarah, Age 9
8 modules: 6 actions, 1 sensor
1 socket mesh
3 lo-fi pieces + lacrosse stick



MAKERWEAR FINAL PROJECT

“NEXT GEN RUNNING CLOTHES”

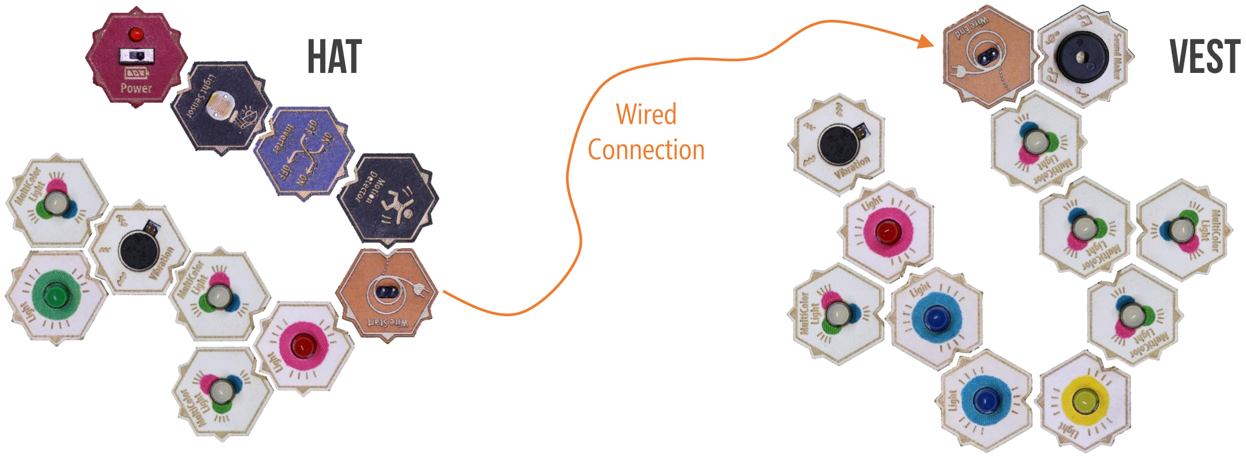



-8=2-x
√4
√49

NEXT GENERATION RUNNING CLOTHES

Maker: Amelia, Age 10
40 modules: 25 actions, 3 sensors, 5 modifiers
4 socket meshes; 2 lo-fi pieces

MOTION-REACTIVE LIGHT-UP SAFETY HAT & VEST



“AIR CONDITIONING” ARMBAND

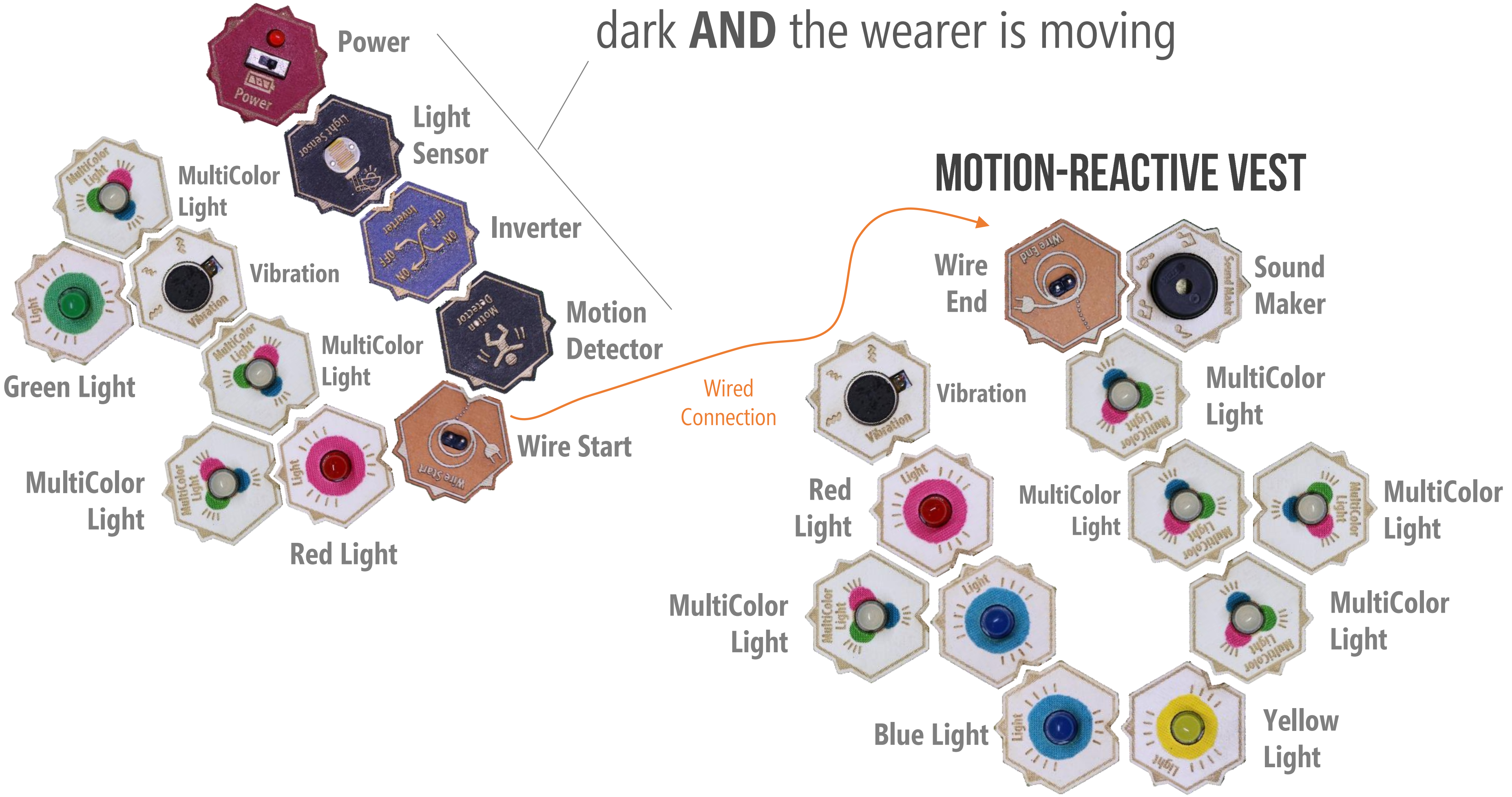
“HEART TRACKER” ARMBAND

NEXT GENERATION RUNNING CLOTHES

Maker: Amelia, Age 10
40 modules: 25 actions, 3 sensors, 5 modifiers
4 socket meshes; 2 lo-fi pieces

MOTION-REACTIVE HAT

Activate hat & vest only when it's dark **AND** the wearer is moving



NEXT GENERATION RUNNING CLOTHES

Maker: Amelia, Age 10
40 modules: 25 actions, 3 sensors, 5 modifiers
4 socket meshes; 2 lo-fi pieces

"HEART TRACKER" ARMBAND

Finally, some unexpected things


CUSTOM OSCILLATOR
8 year old maker


CUSTOM OSCILLATOR
8 year old maker

MUSEUM EXHIBIT

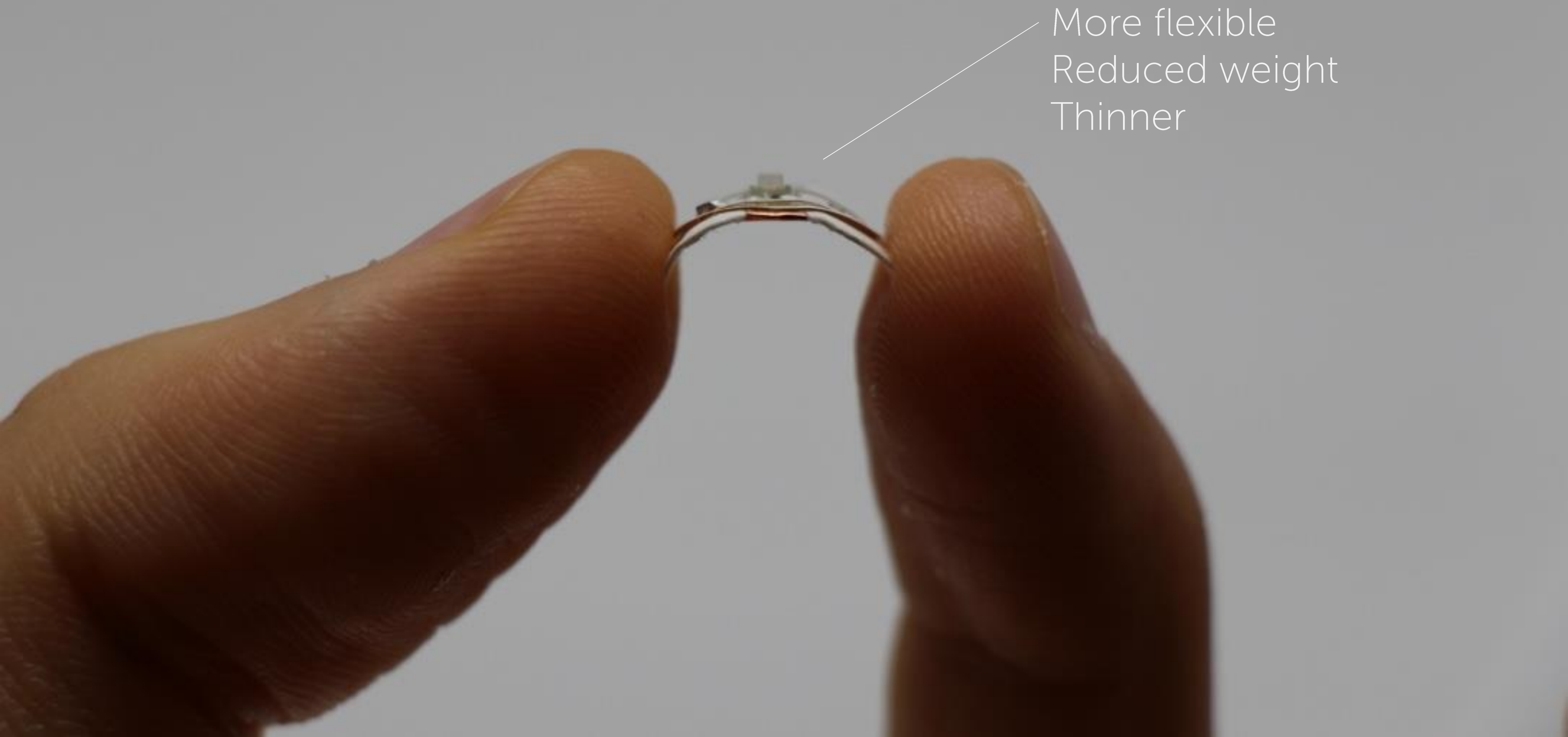
4 year old maker

"[he] hasn't been captivated like that for any other activity in the museum"

MAKERWEAR FUTURE WORK

MAKERWEAR FUTURE WORK

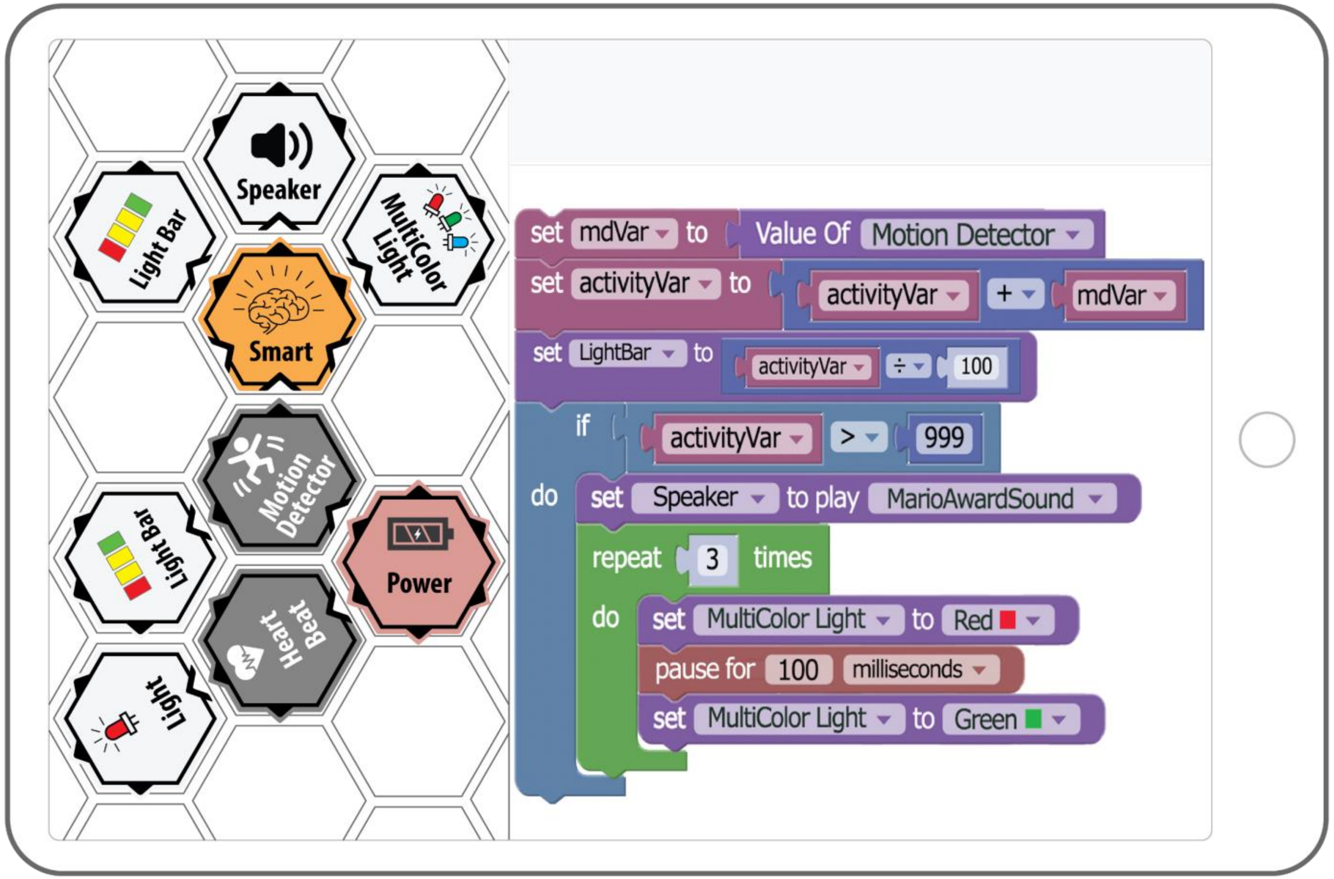
FORM FACTOR



FUTURE WORK

HYBRID TANGIBLE-GRAPHICAL PROGRAMMING INTERFACE

Modules will be wirelessly programmable via a custom tablet programming interface

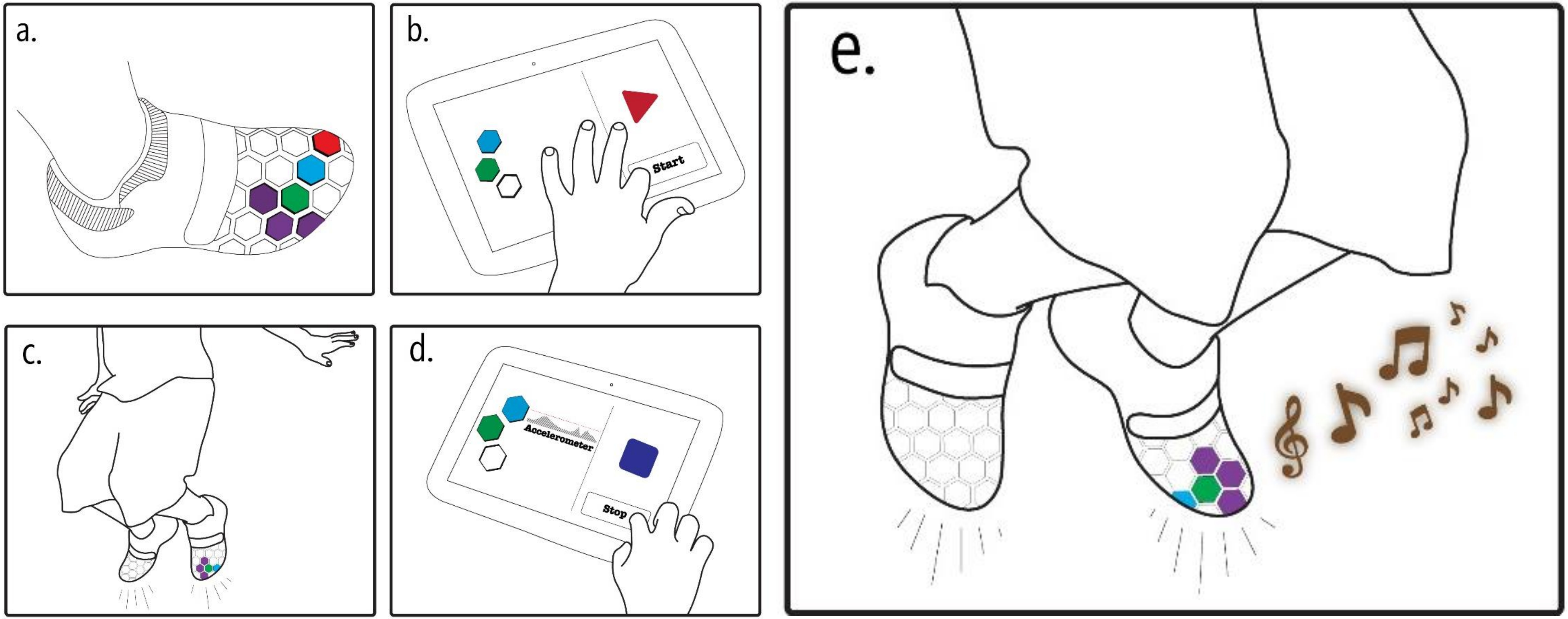


Sample Application:
Making a fitness tracker using a *Motion Detector* and a *HeartBeat Detector*.

FUTURE WORK

INTERACTIVE MACHINE LEARNING

Children can program complex behavior via a novel machine learning interface



MAKEABILITY LAB

FOUR FOCUS AREAS

ENVIRONMENTAL SUSTAINABILITY

HEALTH & WELLNESS

ACCESSIBILITY

STEM EDUCATION

ACKNOWLEDGEMENTS

PARTNERS

KID MUSEUM

BOYS & GIRLS CLUBS

futuremakers

KIDS MAKE THINGS BETTER™.COM

CYC Center for Young Children

PGCPS

Great By Choice

Prince George's County Public School System

WE ARE CASA

CASA

SOMOS CASA

UNIVERSITY OF MARYLAND 1856

COLLEGE OF EDUCATION

STEM Masters in Education Program

University of Maryland Kidsteam

ACKNOWLEDGEMENTS

FUNDING SOURCES

Congressionally Directed Medical Research

MAPPING ACCESSIBILITY OF THE WORLD
NSF #1302338, Google, IBM
PI Froehlich, Co-PI David Jacobs

BODYVIS & SHAREDPHYS
NSF #1441184
PI Froehlich, Co-PI Tamara Clegg

HMD SOUND AWARENESS
Google Faculty Research Award
PI Leah Findlater, Co-PI Froehlich

MAKERWEAR
NSF CAREER #1652339
PI Froehlich

HANDSIGHT TOUCH VISION
Department of Defense CDMRP
PI Froehlich, Co-PIs Leah Findlater & Rama Chellappa

ACKNOWLEDGEMENTS

IMAGE CREDITS

All photos by Jon Froehlich or Makeability Lab students except

REUTERS/Muzaffar Salman

Found http://www.businessinsider.com/us-trusts-10-lessons-of-2013-2013-12

Unknown

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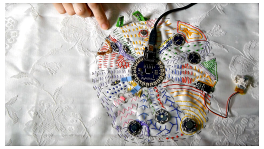


LilyPad Arduino Interactive Pad by Agy Lee

Found https://youtu.be/agYGhwc3NOk

Electronic Fashion Camp by Amy Florence

Found https://www.flickr.com/photos/amypickup/sets/72157631039891148/with/7769553484/

I Heart LilyPad Arduino by Rain Ashford

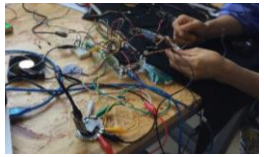
Found https://www.slideshare.net/Rainycat/i-lt3-lilypad-Arduino

Manual Sewing Skills by Leah Buechley

Found https://www.flickr.com/photos/leahbuechley/2595747031/

Example E-Textile Projects

Please see the respective PowerPoint slide in the notes section for attributions



Thinking Fabrics by Cindy Hu

Found http://ima.nyu.sh/documentation/author/yh1437/

Girls Make It

Found http://www.girlsmakeit.org/

Leaf by Thomas Helbig

Found https://thenounproject.com/search/?q=environmental+sustainability&i=120238

Health by Timothy Miller

Found https://thenounproject.com/search/?q=health&i=396737

Accessible Icon Project

Found http://accessibleicon.org/#use

Microscope

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MAKING WITH A SOCIAL PURPOSE
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Computer
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