Incorporating Information from Trusted Sources to Enhance Urban Navigation for Blind Travelers

Byung-Cheol Min[1], Suryansh Saxena[2], Aaron Steinfeld[1], and M. Bernardine Dias[1]

[1] The Robotics Institute, Carnegie Mellon University

[2] Delhi Technological University

Navigating Unfamiliar Environments

Figure 1: Strategies blind travelers utilize to navigate

- 285 million people in the world are visually impaired

- Limited tools for navigation; limited accessibility

- Day-to-day activities such as using transit systems (e.g. airports, train stations, bus depots, etc.) remain challenging tasks for visually impaired

Objectives

- Realize smart cities of the future that are truly accessible and navigable by everyone, including people with disabilities.

- Introduce a framework for blind travelers to add map/navigation information to the tool, and to invite trusted sources to do the same.
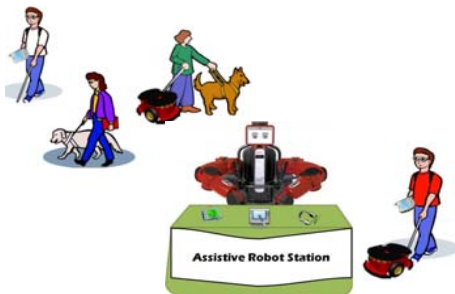

Figure 2: Illustration of blind travelers in future cities
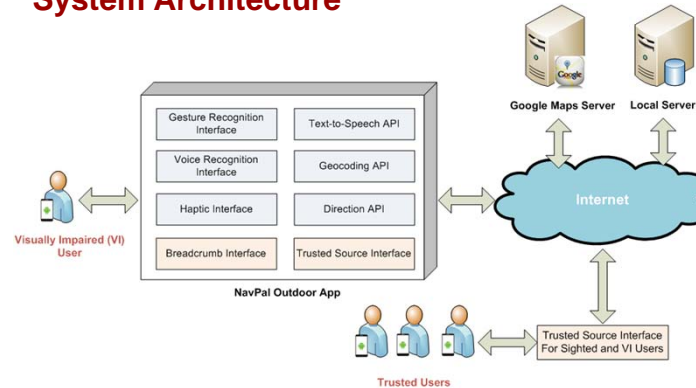
System Architecture

Figure 3: System architecture

- **Audio Breadcrumbs**: Visually impaired travelers are able to Annotate/Record/Share useful information

- **Trust Sources**: Trusted individuals can share their observation on the dynamic change

Iterative Design

- **Participants**: 4 blind and visually impaired travelers
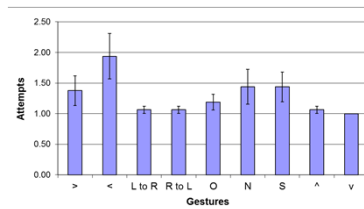
- **Techniques**: In person interviews

- **Results**:

Figure 4: Gesture testing

Participant	Test 1 (n=3)	(3)	Test 2 (2)
P1	3	3	2
P2	1	2	2
P3	2	3	2
P4	0	2	-
Average	1.5	2.5	2

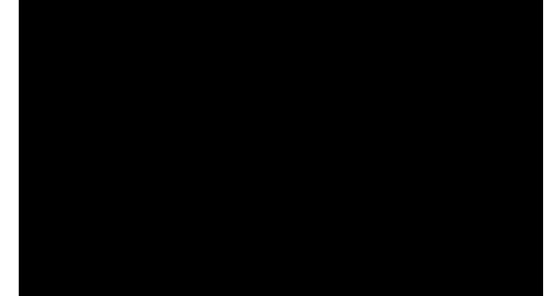| Participant /Item	[a] Speech	[b] Voice	[c] Gesture	[d] Overall
P1	5	4	5	9
P2	5	3	5	8
P3	4	4	5	9
P4	2	4	4	6
Average	4	3.75	4.5	8

Figure 5: Usability studies and user scores on the app

NavPal Project Website

www.cs.cmu.edu/~navpal

Use-case Scenarios

- **Audio Breadcrumbs**
  – Pittsburgh PA, USA

Video 1: Demonstration on adding an audio breadcrumbs

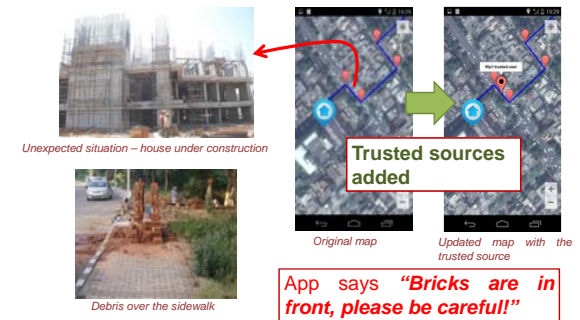- **Trust Sources**
  – Delhi, INDIA

Unexpected situation – house under construction

Debris over the sidewalk

Original map

Updated map with the trusted source

Trusted sources added

App says **"Bricks are in front, please be careful!"**

Figure 5: Demonstration on trusted sources

Next Steps

- Manage the amount of data that the trusted sources can generate

- Manage information conflicts

- Test with visually impaired users

Acknowledgements

Carnegie Mellon University

TechBridgeWorld

RERC APT

MOTIVATION

- ❑ 285 million people are visually impaired in the world
- ❑ Dynamic changes in unfamiliar environments can make safe and independent urban navigation a challenge
- ❑ Smart cities could potentially enhance the safety and independence during navigation
- ❑ Smartphones are likely to be the primary modality

TechBridgeWorld ©

Blind adult interacting with smartphone-based navigation app

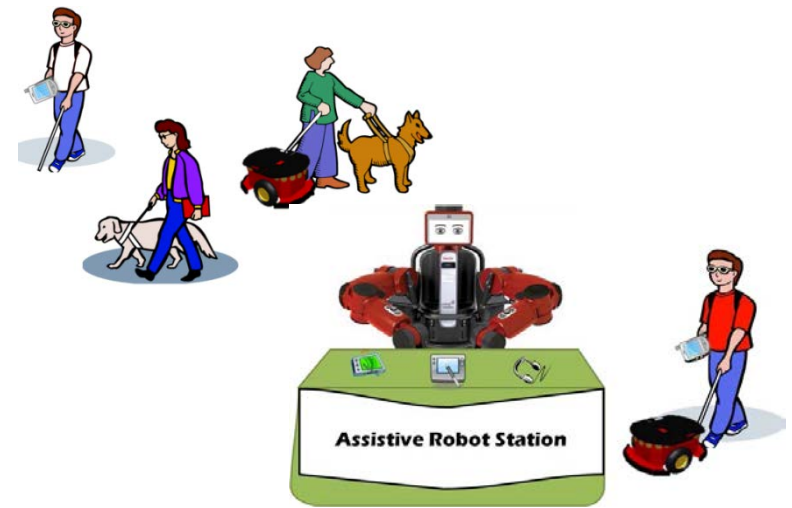Assistive Robot Station

Illustration of blind travelers in future smart cities

RELATED WORK

- ❑ White Cane
- ❑ Dog Guide
- ❑ Smart Phone-based Navigation Tools
    - ❑ NavPal Indoor App
    - ❑ BlindSquare, Ariadne, Loadstone, etc
- ❑ Crowdsourcing Approaches
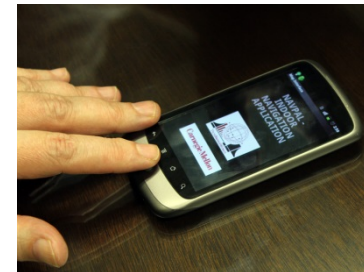   - ❑ VizWiz
    - ❑ Tiramisu
    - ❑ Blind Leading the Blind

ISSUES:
- ❑ Not point-to-point navigation
- ❑ Inflexible to deal with dynamic changes
- ❑ Hard to discern if the information is trustworthy

This Image from *

Strategies blind travelers utilize to navigate

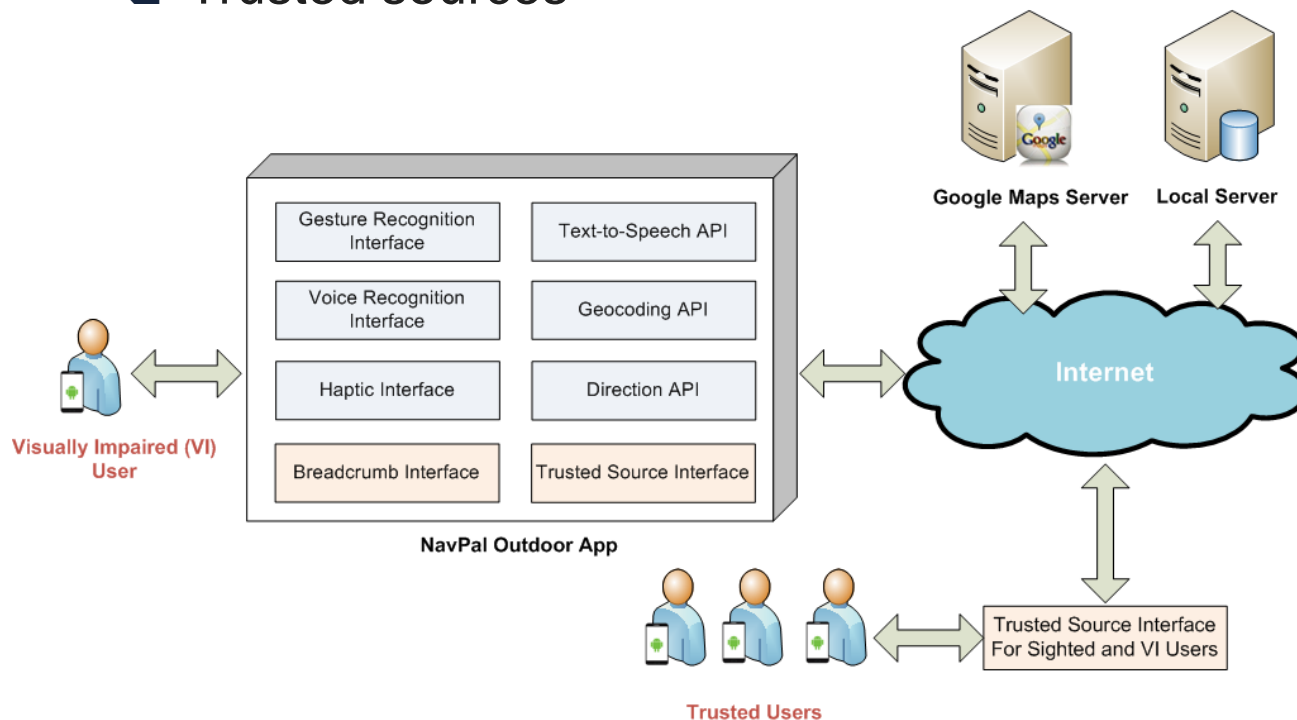

NavPal   *Tiramisu*

BlindSqure   *VizWiz*

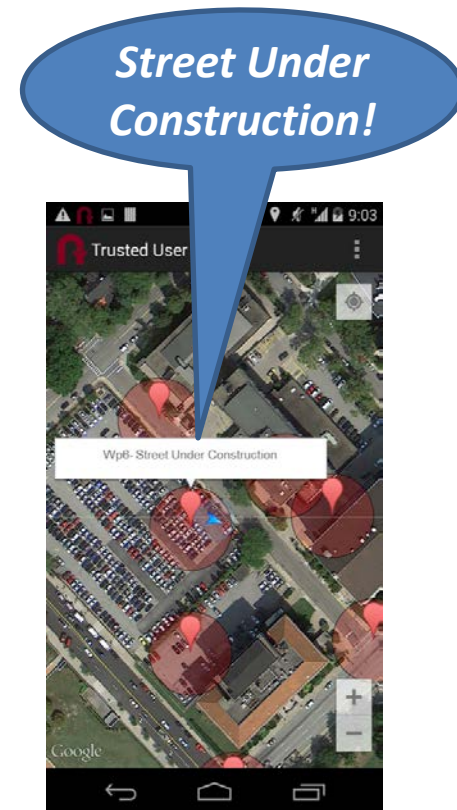* Image source: http://www.dailymail.co.uk/news/article-1043529/Pensioner-lose-guide-dog-walking-slowly.html

RESEARCH GOAL

❏ Introduce a mechanism for blind travelers to enhance the performance of a smartphone-based navigation tool by
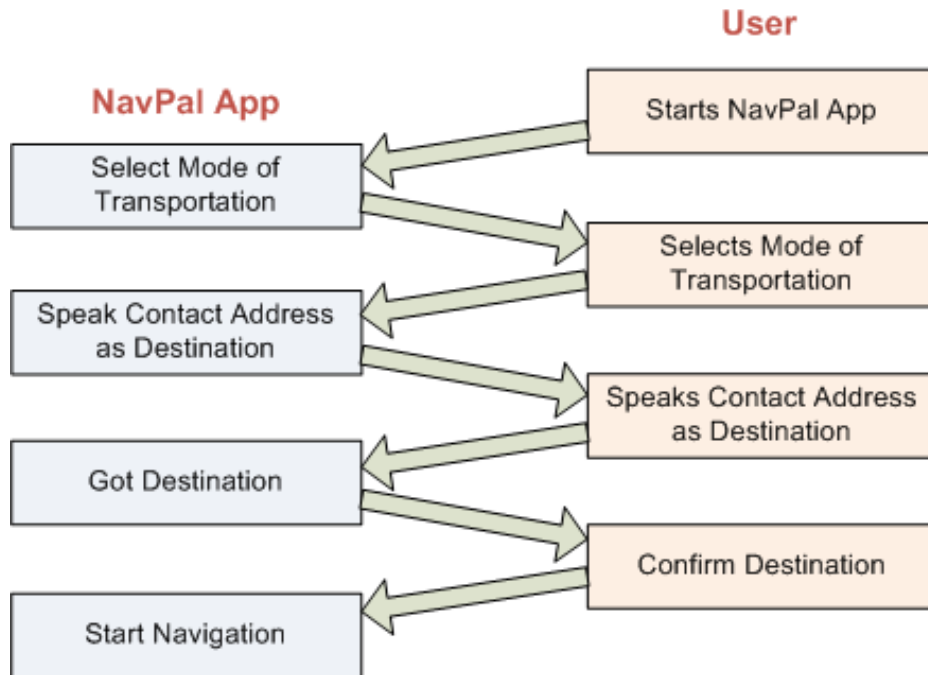 ❏ Breadcrumb annotations
  ❏ Trusted sources

Street Under Construction!

System Architecture of the NavPal outdoor app
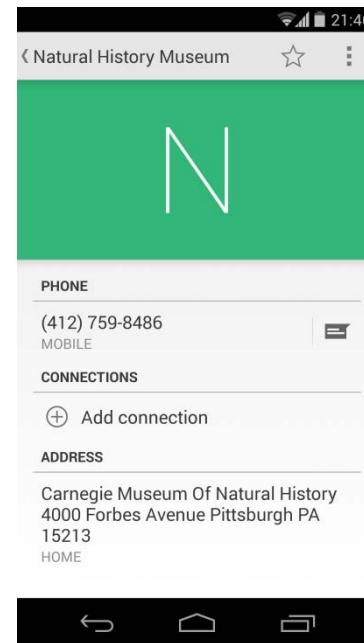
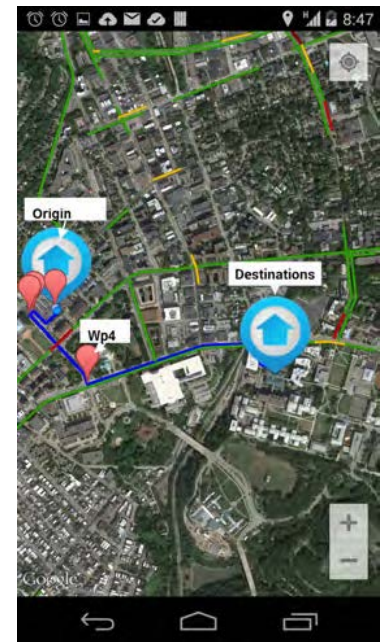*Example of useful annotation added*

NavPal Outdoor App

Interactions between the NavPal outdoor app and the user
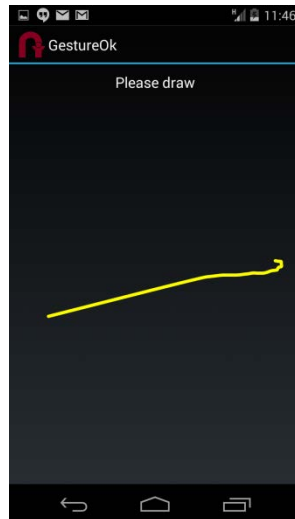

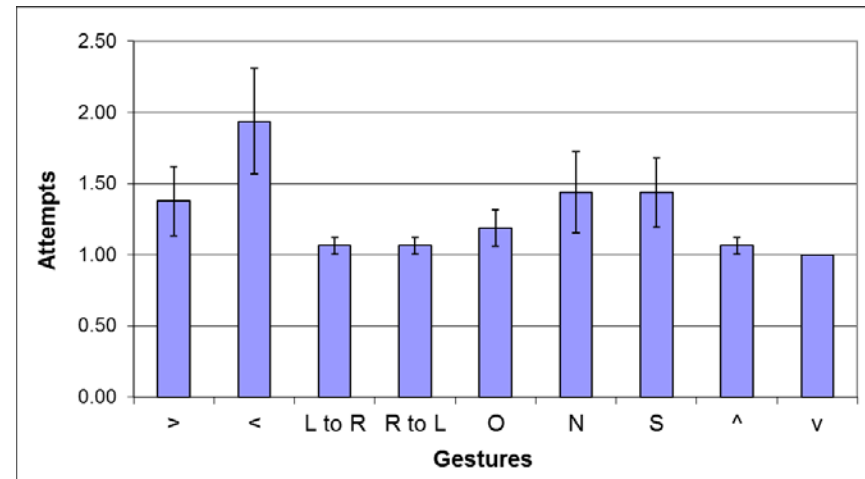Contact name and address

Snapshot of NavPal outdoor app

ITERATIVE DESIGN

- Conducted with 4 participants (3 blind; 1 visually impaired)
- Input via on-screen gestures

Gesture drawn on the screen

Gestures: >, <, swipe right, swipe left, O, N, S, ^, v

Summarized results form gesture testing

RESULTS Troublesome gesture: *<, N, S, and >*
Performed correctly: *swipe right, swipe left, ^, v, O*
Preferred directional swiping with one or two fingers

ITERATIVE DESIGN

❑ Overall accessibility of interface
- a) Input the transportation medium
- b) Speak the contact name
- c) Use gestures
- d) Speak an address location
- e) Navigate on the map by gestures

Participant	Attempt1	Attempt2	Attempt3
	(a) - (c)		(d),(e)
P1	3/3	3/3	2/2
P2	1/3	2/3	2/2
P3	2/3	3/3	2/2
P4	0/3	2/3	-
Average	1.5/3	2.5/3	2/2

*Usability studies on the NavPal outdoor app*

❑ Feedback
- a) Speech recognition
- b) Voice instruction
- c) Gesture instruction
- d) Overall performance

| Participant /Item	(a) Speech	(b) Voice	(c) Gesture	(d) Overall
P1	5/5	4/5	5/5	9/10
P2	5/5	3/5	5/5	8/10
P3	4/5	4/5	5/5	9/10
P4	2/5	4/5	4/5	6/10
Average	4/5	3.75/5	4.75/5	8/10

User score on the NavPal Outdoor app
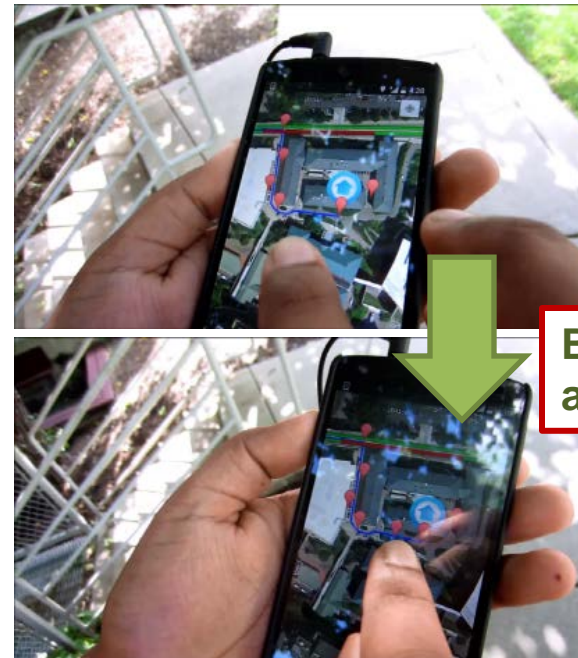
BREADCRUMBS APPROACH

- ❑ Concept – Visually impaired travelers are able to
  - ❑ Annotate their routes on maps
  - ❑ Record other information that will be useful for future trips to the same location
  - ❑ Share this customized information with others who may find it useful
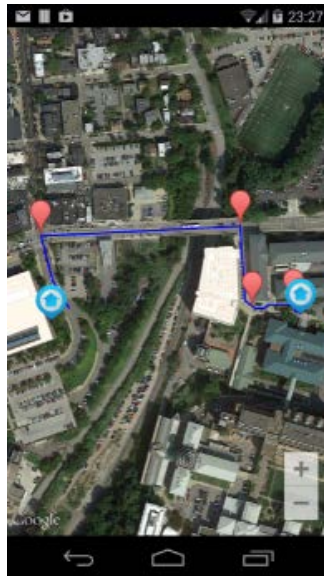
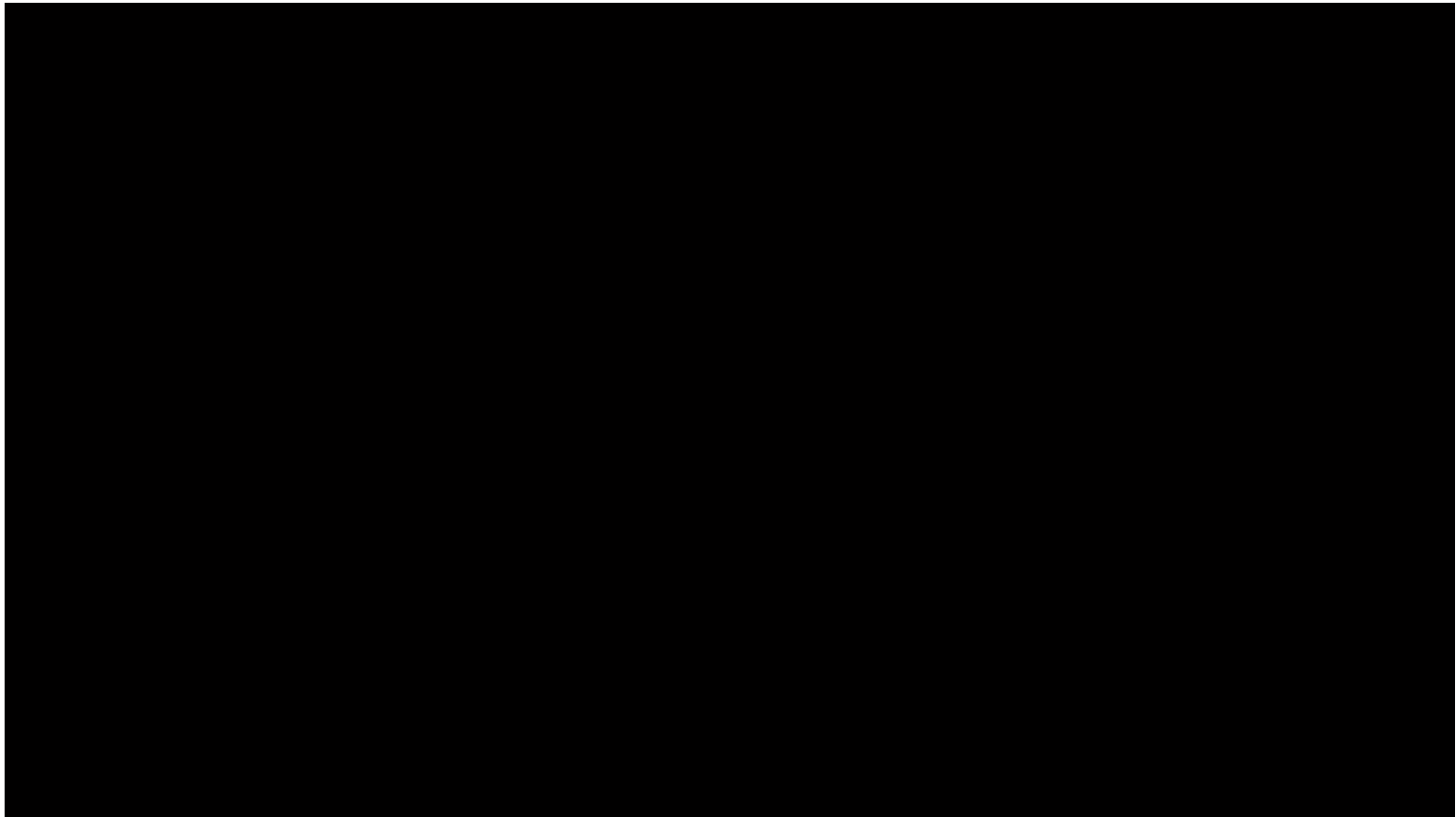*Snapshot of NavPal outdoor app*
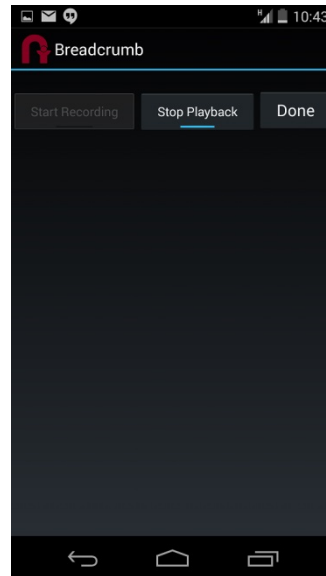
Breadcrumb Interface

Original map

Breadcrumb annotation added

Updated map

BREADCRUMBS APPROACH

❑ Demo – Use-case scenario for breadcrumbs* ([Link](#))

* A full video is available at: https://www.youtube.com/watch?v=h8qs86OEzxo

A NETWORK OF TRUSTED SOURCES

- ❑ Concept - Trusted individuals can share their observation on the dynamic change in the environment with blind travelers via the connected network like Internet

- ❑ Trusted individuals could be government officers, property managers, O&M experts, friends of the visually impaired traveler, or visually impaired users themselves

*System Architecture of the NavPal outdoor app*
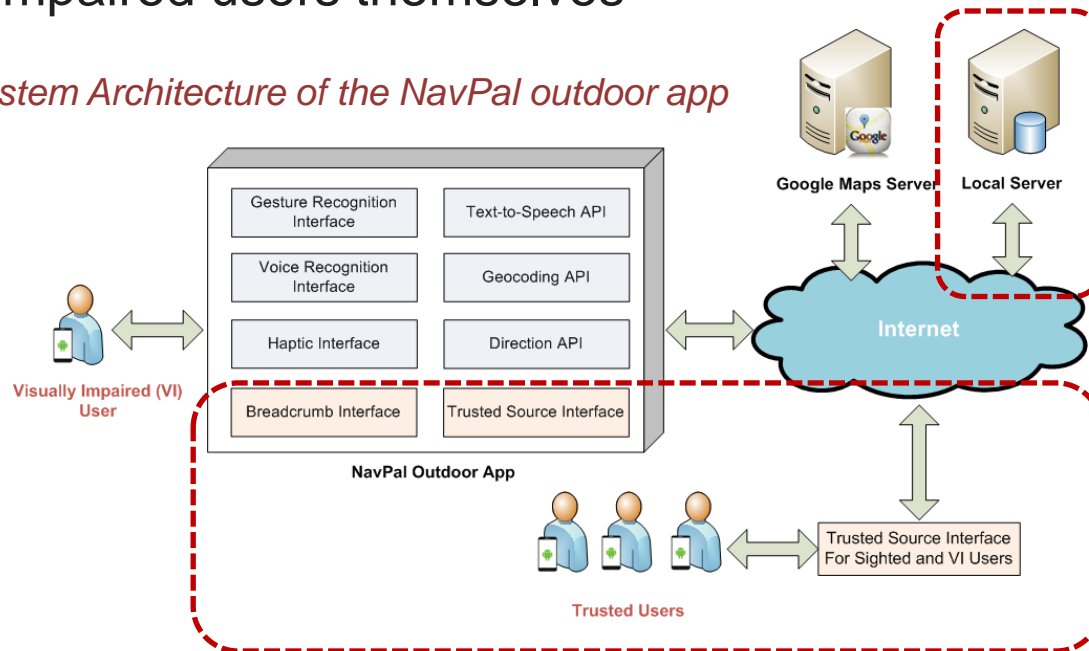
A NETWORK OF TRUSTED SOURCES

❑ Trusted individual can select different attributes of the Point-of-Interest (POI). For example,

   ❑ Is this POI blocking the path of the user?

   ❑ What is a proximity to this POI?

   ❑ Life span of the POI

❑ Users can designate trusted sources

   ❑ Contact name and address

System Architecture of the NavPal outdoor app
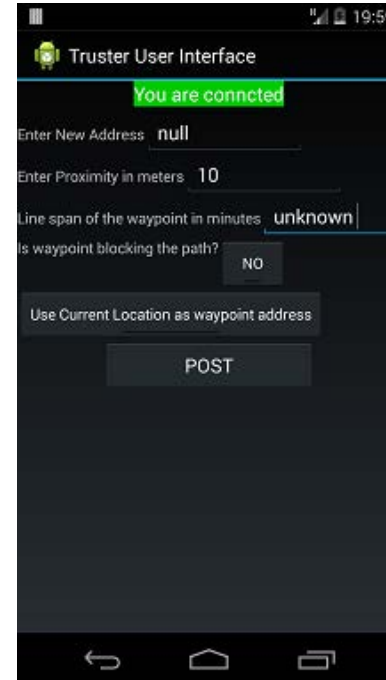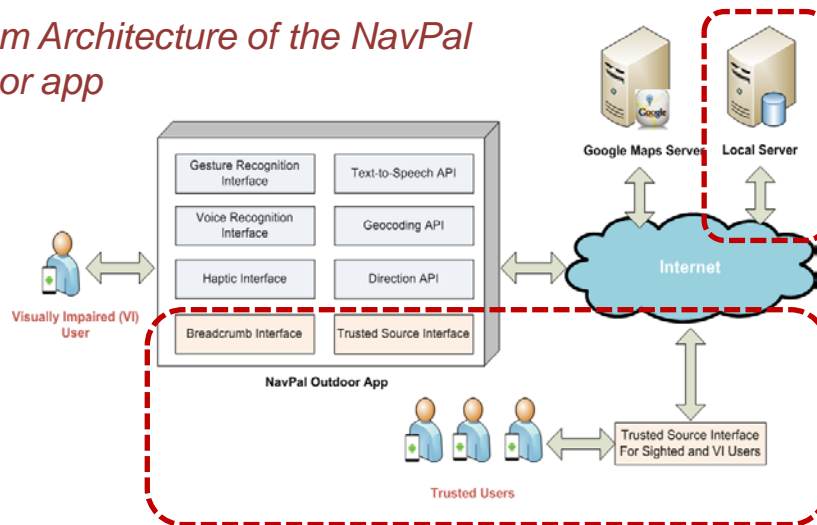
Trusted user interface for sighted users
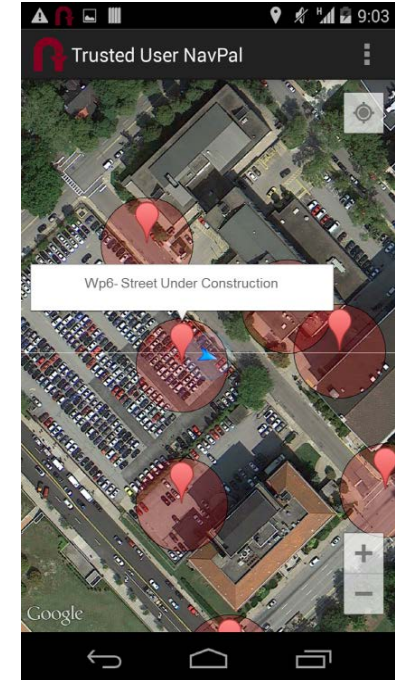
Example of trusted sources added
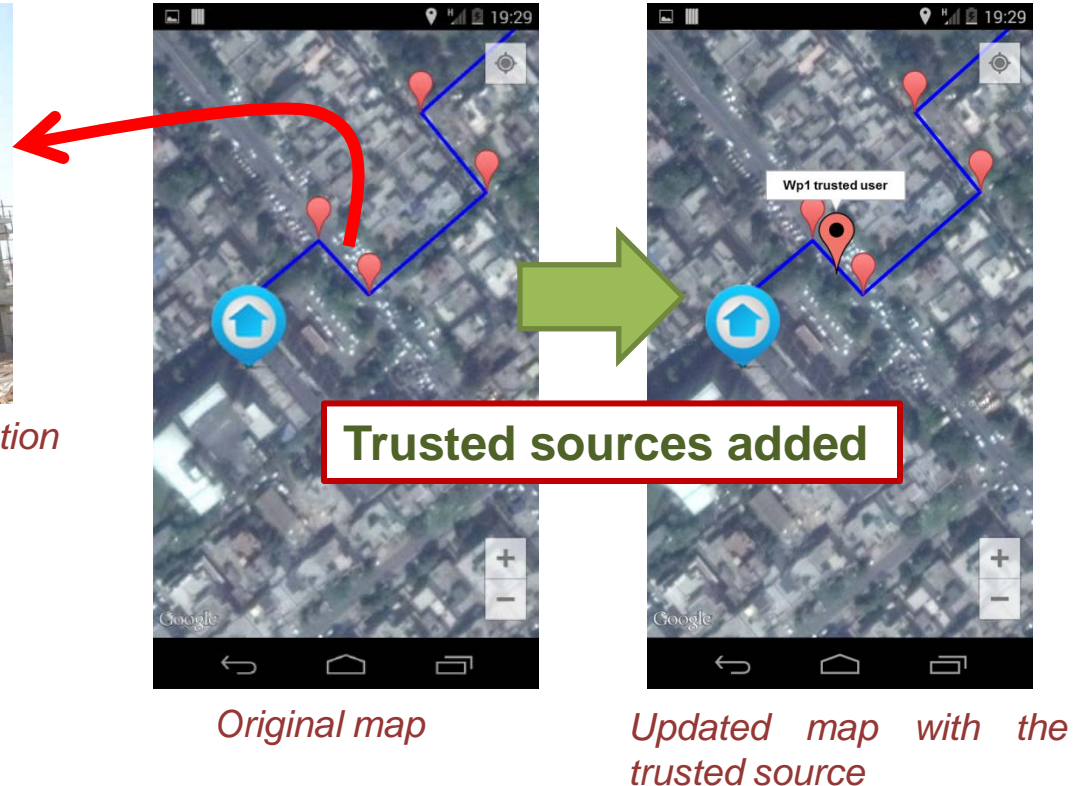
A NETWORK OF TRUSTED SOURCES

❑ Use-case scenario for a network of trusted sources

Unexpected situation – house under construction

Debris over the sidewalk

Trusted sources added

Original map

Updated map with the trusted source

NavPal app says *"Bricks are in front, please be careful!"*

SUMMARY AND FUTURE WORK

- ❑ Summary
  - ❑ Proposed a mechanism of Trusted Sources and Breadcrumb Annotation
  - ❑ Developed prototype of a smartphone-based navigation tool
  - ❑ Implemented the key functions

- ❑ Future work
  - ❑ Manage the amount of data that the trusted sources can generate
  - ❑ Manage information conflicts
  - ❑ Remove the dependence of the Google servers
  - ❑ Test with visually impaired users

System architecture
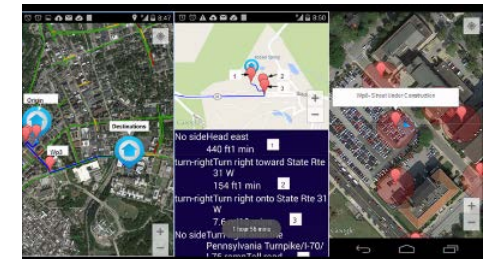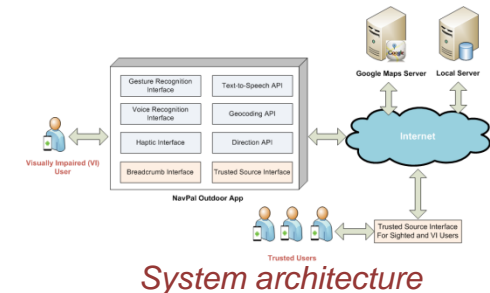
Smartphone-based navigation tool

Implementation of Breadcrumb annotation

ACKNOWLEDGMENTS

❑ This work was funded by
- ❑ A grant (H133E080019) from the United States Department of Education through the National Institute on Disability and Rehabilitation Research
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❑ We thank
- ❑ Our project partners - Western Pennsylvania School for Blind Children (WPSBC) and Blind and Vision Rehabilitation Services of Pittsburgh (BVRSP)
- ❑ The participants in the user studies that informed this work
- ❑ Suryansh Saxena and Ermine Teves who assisted with different aspects of this work

Questions?

NavPal Project Website

www.cs.cmu.edu/~navpal