Problems: Blind Riders Need Accurate Localization Tools

We propose a computer vision-based system, LastStep, that can localize bus stops with a step-level accuracy.

- Minimizing manual search effort
- Utilizing existing infrastructures
- It complements RF-based systems where deployment is infeasible.
- In conjunction with RF anchors, it potentially increases system reliability and/or accuracy.

Existing systems:
- GPS-based: large variance (5m), extra manual search required
- RF-based: environmental modifiability required

System Architecture

- Contextual Database
  - Key points of signs
  - Physical size of signs
  - Fine-grained maps

- Smartphone
  - Capture images
  - Detect signs
  - Estimate 3D projection
  - Estimate gravity vector
  - Localize on maps
  - Provide verbal feedback

- Web Interface
  - Display GE and GSV
  - Label objects
  - Generate bus stop fine-grained maps

- The entire front-end is in one COTS smartphone.
- Minimal setup: parameters of signs can be shared between the same type (in a city/county).
- Scalable: using a combination of Google Earth and Google Street View to generate bus stop maps.

Crowdsourcing: Annotate the Topology Map

- Human workers annotate objects in a bus stop with Google Earth data.
- They can "zoom in" to Google Street View to identify the objects.

Comparing the results obtained from Amazon Mechanical Turk to experts' annotations.

Test on Emulated Human Participants

- Evaluating on three participants, emulated (blind-folded)
- Participants perform searching in 6 sites, with or without our system. Search time is recorded in unit of minute.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Sites</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
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<td>4.1</td>
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<td>1.7</td>
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<td>w/0</td>
<td>4</td>
<td>X</td>
<td>X</td>
<td>10.5</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>B</td>
<td>w</td>
<td>1.6</td>
<td>3.5</td>
<td>1.3</td>
<td>1.9</td>
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<td>C</td>
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"X" means that participant admitted failure after 10 min.
- It shows a higher success rate (17/18) and higher speed (4 times faster) with our system.

Conclusion

- We present LastStep, an accurate and infrastructure-modification-free localization system for blind riders.
- It performs localization with an step-level accuracy.
- Less than 0.5 meters error
- With LastStep, participants can perform localization with a higher success rate and 4 times faster than manual searching.