COMMUNISENSE: Crowdsourcing Road Hazards in Nairobi

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Outline

- **Introduction**
  - Potholes (PT) & Speed-bumps (SB)
- Methodology
- Results
- Novelty and Challenges
- Critiques
Introduction

● Motivation

- Nairobi currently *lacks* monitoring technologies to obtain data on road conditions.

- Such as Potholes and/or Speed-bump.
Introduction

- Road hazard: Potholes (PT)

(a) Potholes
Road Hazard Examples

- Road hazard: Speed-bump (SB)
Outline

- Introduction
- **Methodology**
  - Survey
  - The App: CommuniSense
  - Image Verification: MTurk
- Results
- Novelty and Challenges
- Critiques
Methodology

• Two types of survey
  • SMS (mSurvey)
  • Web-based (gSurvey)

• On the opinions of road situation
  • Road quality around home/work
  • Impact of road hazards
Survey

- Status quo on road quality

Road quality in residential neighborhood

Potholes as a major road nuisance

Impact of road hazards on personal travel discomfort
CommuniSense Frontend

- CommuniSense: Hazard report submission
CommuniSense Frontend

- CommuniSense: Mapping hazards

- PH: Potholes
- SB: speed-bumps

(b) Mapping Hazards
CommuniSense Backend

External
- OpenStreetMaps, OpenData
- Nairobi City Council
- Visualization Platform

External API

Data Collection
- Other Mobile Apps
- CommuniSense

Data Pre-Processing
- Sensor Data
- Hazard Images
- Hazard Reports

PHP Server
- Cloudant CouchDB
- Bluemix Mysql DB

Data Post Processing

Internal System

Backup Server
Data Statistic

Severity of potholes
(61 reports)

Labeling of speed-bumps
(38 reports)
Data Statistic

(a) Severity of potholes (61 reports)

(b) Labeling of speed-bumps (38 reports)
Data Statistic

Severity of potholes
(61 reports)

Labeling of speed-bumps
(38 reports)
Image Verification: MTurk

- **Mechanical Turk is a marketplace for work.**
  We give businesses and developers access to an on-demand, scalable workforce.
  Workers select from thousands of tasks and work whenever it’s convenient.

- **395,733 HITs** available. [View them now.](#)

- HIT: Human Intelligence Task
- 0.15 USD per Image, around $12 per hour.
- Required to check the description and the pictures are corresponding to each other.
Outline

● Introduction
● Methodology
● Results
  ● Two Aggregation Methods
  ● Intraclass Correlation (ICC)
  ● OpenStreetMap (OSM)
● Novelty and Challenges
● Critiques
Results: Image Label Quality

- Aggregation methods:
  - Majority Vote
    - Calculate the majority score given the 10 annotations for each image
  - Median
    - Calculate the median across the 10 annotations for each image.
  - Among 50 images:

<table>
<thead>
<tr>
<th>Method</th>
<th>Potholes</th>
<th>Speed Bumps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Majority Voting</td>
<td>34 (100%)</td>
<td>12 (75%)</td>
</tr>
<tr>
<td>Median</td>
<td>34 (100%)</td>
<td>12 (75%)</td>
</tr>
</tbody>
</table>
Results:

- Misclassified Images

(a) Contain both a pothole and a speed-bump

(b) Ambiguous Image with unlabeled bump
Results: Image Label Quality

- **Introclass Correlation (ICC)**
  - Also implemented by Amazon Mturk worker pool.

<table>
<thead>
<tr>
<th></th>
<th>Min (Max)</th>
<th>Mean (Median)</th>
<th>ICC(1, k)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of potholes</td>
<td>1.0 (3.0)</td>
<td>2.16 (2.0)</td>
<td>0.90</td>
</tr>
<tr>
<td>Severity of potholes</td>
<td>1.0 (4.0)</td>
<td>2.26 (2.0)</td>
<td>0.91</td>
</tr>
<tr>
<td>Size of speed-bumps</td>
<td>1.0 (3.0)</td>
<td>1.92 (2.0)</td>
<td>0.73</td>
</tr>
</tbody>
</table>

Table 2: ICC(1, k) scores of hazard attributes (All values are statistically significant at $p < 0.01$.) Mean and median (in brackets) values of each hazard attribute is also shown.
Results: Visualization Framework

- OpenstreetMap (OSM): layered and interactive
Outline

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- Results
- **Novelty and Challenges**
- Critiques
Novelty and Challenges

- **Novelty and Future Work**
  - Most similar systems are not available for Nairobi.
  - May use Twitter as a data collection medium in the future.

- **Challenges:**
  - Certain devices didn’t handle the mapping and location functionality well.
  - CommuniSense is developed on Android 3.0, while many phones are still using Android 2.x.
  - The *base64* compression causes loss of image dependent on the orientation (landscape vs. portrait mode).
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Critiques

- Simple App
- Good solution for Kenya. No good alternative, only a Twitter account called *ma3route*.
- May be used in other areas.
Critiques

- Use Mturk (slave labors). Should find an automatic way.
- Exist systems which allow citizens to report civic issues
  - SeeClickFix
  - FixMyStreet
  - Citizens Connect
References

Thank You