Integrated Crowdsourcing Platform to Investigate Non-Motorized Behavior and Risk Factors on Walking, Running, and Cycling Routes

Jun 21, 2016
Faculty
- Ala Al-Fuqaha, Professor, Computer Science, WMU
- Jun-Seok Oh, Professor, Civil engineering, WMU
- Valerian Kwigizile, Associate Professor, Civil Engineering, WMU

Student Investigators:
- Spideh Mohammadi, Master’s Student, Computer Science, WMU
- Fadi Alhomaidat, Ph.D. student, Civil Engineering, WMU
Goals

- Inform the public about potential risk factors on cycling routes and public infrastructure.
- Inform city/county officers about risk factors on cycling routes in their areas of interest.
- Estimate traffic volume and benefit from the wisdom of the crowd (i.e., crowd sensing).
Our Research
“Mapping cyclist activity and injury risk in a network combining smartphone GPS data and bicycle counts”

- Jillian Strausssa, LuisF.Miranda-Morenoa, PatrickMorencyb
  - This study aimed to estimate bicycle volume and injury risk in the network by using smartphone GPS, manual counts, inductive loops and pneumatic tubes.
  - This method is limited for certain areas or times. Users can’t report risk factors. However, the accuracy is high and the cost and coverage are low.

“A multiple inductive loop vehicle detection system for heterogeneous and lane-less traffic”

- S.sheik mohammed , IEEE 2012
  - This study proposed the use of multiple inductive loop sensors that can sense different vehicles. It basically includes two loops inner and outer. The inner loop is small and used to sense small metallic objects (i.e., bicycles).
  - This method is relatively accurate, however it does not cover a large area and is somewhat expensive.
“Automated Bicycle Counts (Lessons from Boulder, Colorado)
Transportation research board”
  - Krista Nordback and Bruce N. Janson, 2010
    - The purpose of this study is to examine the inductive loop accuracy after a number of years of use by comparing it with manual count data. Inductive loop data showed 4% lower count data compared to manual count.
    - Therefore, we can conclude that even the inductive loop might provide inaccurate data over time. Besides, both methods are relatively expensive compared to mobile sensors.

“Using a bicycle-pedestrian count to assess active living in downtown Wilkes-Barre”
  - American journal of preventive medicine (2012)
    - This study was intended to count the pedestrian and bicycle volume in downtown Wilkes-Barre. The study was conducted over 4 days (2 hours per day) and included 7 counting sites.
    - This method is limited to a small geographic area and is relatively costly but the accuracy is relatively high.
“Volunteered geographic information: future research directions motivated by critical, participatory, and feminist GIS”
  - Sarah Elwood, 2008
    - Geo-crowdsourcing: data collected by ordinary citizens through digital mapping (via a web-interface).
    - VGI offers an innovative digital technology approach to enriching available data for a wide-range of research and planning applications.

“BikeMaps.org: a global tool for collision and near miss mapping”
  - Nelson et al., 2015
    - Main goal is to collect data about bicycle safety and risk. Website was developed to allow users to map cycling collisions and near misses.
    - It does not allow users to report risk factor through a mobile app. Also, it does not have the ability to inform local authorities about local hazards. Besides, it does not have the ability to estimate traffic volume.
Risk factor Categories

- Infrastructure-Related
- Traffic-Related
- Facility-Related
Infrastructure-related risk factors

- Lack of dedicated bicycle lanes
- Lack of shared bicycle lane signs
- Lack of grade separated cycling paths (separated from motor vehicle and pedestrian)
  - Narrow bicycle lanes
  - Bus stop on bicycle lane
  - Right-Turn channelization (bike lane being between right-turn and through lanes)
  - Stairways
- Wheel-trapping catch-basin grates, gutters, and drainage grates (parallel bars)
- Pavement rutting
- Drop offs at overlays (uneven pavement)
- Open drainage ditches across the street
- Unpaved driveway and roads
- Unsmooth patches
- Wide pavement joints
- Steep sloped gutters
- Unsafe railroad crossing (not at right angle)
- Pavement friction (slippery wet pavement)
- Potholes
- Pavement cracking
- Standing water
Traffic-related risk factors

- Lack of bicycle detectors at signalized intersection
- High speed traffic
- High volume traffic
- Inadequate cycle length
- Invisibility of traffic light
- Aggressive driver behavior
Facility-related risk factors

- Unpruned trees and overgrowing vegetation.
- Speed bumps
- Rumble strips
- Insufficient lighting
- Absence bike racks
- Lack of signage devoted to bike traffic.
- Lack of information about existing facilities (i.e. maps)
- Raised lane markers
- Curbside auto parking
- Signs too close to roadway
- Blind corners (poor sight distance)
- Poorly managed work zones
Collect feedback from potential users

- Web survey was conducted, in order to collect feedback from potential users regarding the desired features of the mobile app and determine most impact risk factors.
- The survey was sent out to Kalamazoo bicycle group, WMU students and faculties.
- They were asked a series of multiple choice and free response questions.
- There were a total of 182 completed responses of the survey.
- Those who claimed so not ride a bicycle were dropped out from the survey which were 24 participants.
- Those who claimed to have not use a mobile cycling app were asked a different set of questions than those who had.
# Survey Results

<table>
<thead>
<tr>
<th>Answer</th>
<th>percentage(%)</th>
<th>No. of participant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>60.77%</td>
<td>110</td>
</tr>
<tr>
<td>Female</td>
<td>39.23%</td>
<td>71</td>
</tr>
<tr>
<td>Total</td>
<td>100.00%</td>
<td>181</td>
</tr>
</tbody>
</table>

![Gender Distribution Chart](chart.png)
Survey Results:
Age Group and Skill-Level

**Age group participants**

- Under 16: 0.00%
- 16-24: 22.53%
- 25-34: 19.23%
- 35-49: 21.43%
- 50-64: 28.02%
- 65+: 8.79%

**How would you classify yourself as a biker?**

- Beginner: 46.84%
- Intermediate: 43.67%
- Experienced: 9.49%
Survey Results: Biker experience

How often do you bike?

- Every day: 10.99%
- At least once a week: 42.31%
- At least once a month: 18.13%
- At least once a year: 15.38%
- I do not ride a bicycle: 13.19%

What the primary purpose of your bike trips?

- Exercise and health: 35.00%
- Recreation: 30.00%
- Commuting (Work/School): 20.00%
- Errands/Shopping: 15.00%
- Other: 10.00%
Survey Results: Cycling App Usage

How frequently do you use a mobile cycling app?

- Never: 66.46%
- Infrequently: 15.82%
- Somewhat frequently: 3.80%
- Frequently: 3.16%
- Very frequently: 10.76%

Which mobile cycling app do you use?

- Strava: 32.29%
- MapMyRide: 21.88%
- Runtastic Road Bike Tracker: 11.46%
- Google Maps: 11.46%
- Cyclemeter: 8.33%
- Wahoo Fitness: 2.08%
- BikeComputer: 1.04%
- SeeClickFix: 0.00%
- Other: 1.04%
Survey Results: Useful Mobile App Features

What features do you use in the mobile cycling app?

<table>
<thead>
<tr>
<th>Feature</th>
<th>Not at all useful</th>
<th>Slightly useful</th>
<th>Moderately useful</th>
<th>Very useful</th>
<th>Extremely useful</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maps and tracking</td>
<td>0.00%</td>
<td>7.55%</td>
<td>5.66%</td>
<td>30.19%</td>
<td>56.60%</td>
</tr>
<tr>
<td>Daily information</td>
<td>22.45%</td>
<td>20.41%</td>
<td>24.49%</td>
<td>22.45%</td>
<td>10.20%</td>
</tr>
<tr>
<td>Health tracking features</td>
<td>11.76%</td>
<td>15.69%</td>
<td>17.65%</td>
<td>29.41%</td>
<td>25.49%</td>
</tr>
<tr>
<td>Other features</td>
<td>26.09%</td>
<td>21.74%</td>
<td>26.09%</td>
<td>17.39%</td>
<td>8.70%</td>
</tr>
</tbody>
</table>
Survey Results: Need for Risk Factor Reporting App

would you be interested in a mobile cycling app that allows to report risk factors that you encounter during your ride?

- Yes: 92.45%
- No: 7.55%
Survey Results:
Rank of Infrastructure Risk Factors

Ranking of Infrastructure-Related Risk Factors

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Average Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potholes</td>
<td>3.95</td>
</tr>
<tr>
<td>Pavement rutting</td>
<td>3.55</td>
</tr>
<tr>
<td>Pavement cracking</td>
<td>3.28</td>
</tr>
<tr>
<td>Drop offs at overleys</td>
<td>2.19</td>
</tr>
<tr>
<td>Narrow bicycle lanes</td>
<td>1.97</td>
</tr>
<tr>
<td>Unsmoothed bike lane</td>
<td>1.71</td>
</tr>
<tr>
<td>Right-Turn channelization</td>
<td>1.55</td>
</tr>
<tr>
<td>Standing water</td>
<td>1.47</td>
</tr>
<tr>
<td>Wide pavement joints</td>
<td>1.39</td>
</tr>
<tr>
<td>Unsafe railroad crossing</td>
<td>1.37</td>
</tr>
<tr>
<td>Pavement friction</td>
<td>1.33</td>
</tr>
<tr>
<td>Bus stop on bicycle lane</td>
<td>1.33</td>
</tr>
<tr>
<td>Steep sloped gutters</td>
<td>1.33</td>
</tr>
<tr>
<td>Unpaved driveway</td>
<td>1.33</td>
</tr>
<tr>
<td>Open drainage ditches across the street</td>
<td>1.33</td>
</tr>
<tr>
<td>Stairway</td>
<td>1.33</td>
</tr>
</tbody>
</table>

Western Michigan University
Transportation Research Centre for Livable Community
Survey Results: Rank of Traffic Risk Factors

Ranking of Traffic-related Risk Factors

- Aggressive driver behavior
- High speed traffic
- High volume traffic
- Lack of bicycle signals
- Waiting time at signalized intersection
- Invisibility of traffic light
- Lack of space to pass slow bicyclists

Risk Factor

Average Impact

0.5 1 1.5 2 2.5 3 3.5 4

Aggressive driver behavior | High speed traffic | High volume traffic | Lack of bicycle signals | Waiting time at signalized intersection | Invisibility of traffic light | Lack of space to pass slow bicyclists
Survey Results:
Ranking of Facility Risk Factors

Ranking of Facility-Related Risk Factors

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Average Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unpruned trees and overgrowing vegetation</td>
<td>3</td>
</tr>
<tr>
<td>Lack of signage devoted to bike traffic</td>
<td>3</td>
</tr>
<tr>
<td>Curbside auto parking</td>
<td>3</td>
</tr>
<tr>
<td>Blind corners</td>
<td>3</td>
</tr>
<tr>
<td>Poorly managed work zones</td>
<td>3</td>
</tr>
<tr>
<td>Insufficient lighting</td>
<td>3</td>
</tr>
<tr>
<td>Rumble strips</td>
<td>2</td>
</tr>
<tr>
<td>Speed bumps</td>
<td>2</td>
</tr>
<tr>
<td>Raised lane markers</td>
<td>1</td>
</tr>
<tr>
<td>Signs too sloped to roadway</td>
<td>1</td>
</tr>
</tbody>
</table>

Western Michigan University
Transportation Research Centre for Livable Community
Design and develop mobile app that allows the local community to **report risk factors** on public infrastructure.

The aim of this task to evaluate that local runner and bicyclist communities can serve as a **reliable crowdsourcing** resource to report risk factors on public infrastructure.

We are going to survey selected infrastructure and compare the reported risk factors versus the surveyed ones.
Google App Engine

- Building scalable web application and mobile backend.
- NoSQL datastore, memcache, and a user authentication API.
- App engine will scale our application automatically in response to the amount of traffic it receives.
Collecting Gyroscope and Accelerometer Data

- Gyroscope sensor: Determines orientation
- Accelerometer sensor: Measures non-gravitational acceleration

Why Collect this data?
- Will help us to evaluate routes bikeability vis-à-vis users’ self-reported evaluations and high-end IMU devices.
Use OSM RESTful APIs to Collect GIS data (e.g., way-id and highway tag).

In order to access more accurate data about the roads and the position of reports.
Click on image to send your report
• Show reported hazards through overlay button.
• The reports are shown based on three categories.
  ▪ Infrastructure-related
  ▪ Traffic-related
  ▪ Facility-related
Users’ evaluation of the track is shown as Heatmap
Select Track History from Menu
Choose your track to see its details.
Elevation and other route details are shown on the map.
Users can report enhancements to the app and provide feedback.
Next Steps: Dissemination of the Mobile App

- We plan to work with local authorities (cities and counties) to advertise the mobile-app through posters and email list.

- We will also work closely with local walker, runner and bicyclist clubs to advertise the use of the mobile app.
The aim of this task is to utilize Deep Learning to extract knowledge out of the collected raw data.

We are going to monitor the feeds that collected from monitoring stations and compare it with database.

Three cameras or manual monitoring stations will be used to provide to collect data about the traffic volume and compare it with the mobile app data.
Next Steps: 
Report to Local Authorities

- Local authorities will be provided with secure access to the raw data and its associated aggregate summary statistics over different periods of time.
Thanks

Support our research by downloading the App for beta testing from the following URL:

http://www.bikeableroute.com