Improving Pedestrian Infrastructure Inventory in MA using Mobile LiDAR

Dr. Chengbo Ai
Assistant Professor
Civil and Environmental Engineering
University of Massachusetts Amherst

Dr. Pedro Hernandez
Senior Program Manager
Bicycle and Pedestrian Mobility Team
MassDOT
Outline

**PRESENT**
- Vision
- Objectives
- Existing inventory

**PAST**
- Route 9 pilot study
- Advances in LiDAR assessment

**FUTURE**
- Automated assessment
- How will information be used
Vision

Pedestrian infrastructure is a **vital** transportation facilitator for safe and uninterrupted trips

MassDOT seeks to provide **equitable** accommodation for all modes of transportation, and has been consistently invested in pedestrian infrastructures

**Sources:** MassDOT - DRAFT Massachusetts Pedestrian Transportation Plan
THE 2019 ROUTE 9 STUDY DEMONSTRATED THE FEASIBILITY OF MOBILE LIDAR AS AN EFFICIENT TOOL TO SUPPORT COST-EFFECTIVE INVENTORY UPDATE AND CONDITION ASSESSMENT OF PEDESTRIAN INFRASTRUCTURES MANAGED BY MASSDOT.

THE OBJECTIVES OF THE CURRENT RESEARCH PROJECT ARE TO COLLECT AND PROCESS MOBILE LIDAR DATA, TO VERIFY AND UPDATE THE 1300 MILES OF EXISTING MASSDOT’S SIDEWALK INVENTORY, AND TO INCORPORATE CONDITION INFORMATION INTO THE INVENTORY GEODATABASE.

GEOLOCATED MEASUREMENTS FOR PEDESTRIAN INFRASTRUCTURE WILL BE INTEGRATED WITH GIS-BASED MASSDOT ROAD INVENTORY, AND AID IN PRIORITIZATION OF SIDEWALK MAINTENANCE.
Existing Inventory

• A sidewalk inventory dataset resides within the GIS-based Road Inventory File
  – 1300 miles of sidewalks currently mapped

• Drawbacks of current dataset
  – time-intensive nature of updates
  – lack of condition information
  – lack of ADA compliance information

• Current infrastructure data may not be of quality or level of detail to make informed investment decisions

Sources: MassDOT - DRAFT Massachusetts Pedestrian Transportation Plan
## Condition vs Compliance

### Sidewalk Surface Condition

<table>
<thead>
<tr>
<th>Condition Defects Present on 50' Segment (Avg 10 Panels)</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>100</td>
</tr>
<tr>
<td>Minor Cracking, Spalling, Utility Access</td>
<td>80</td>
</tr>
<tr>
<td>Major Cracking, Vertical Fault 1/2-1&quot;, 2 or more less serious defects</td>
<td>60</td>
</tr>
<tr>
<td>Overgrown cracks, Ponding/sediment deposit, Vertical Fault 1&quot;-3&quot;, 3 or more less serious defects</td>
<td>40</td>
</tr>
<tr>
<td>Root Uplift, Vertical Fault &gt; 3&quot;, 4 or more less serious defects</td>
<td>20</td>
</tr>
</tbody>
</table>

### Sidewalk Width

<table>
<thead>
<tr>
<th>Width</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;5 Feet</td>
<td>100</td>
</tr>
<tr>
<td>4-5 Feet</td>
<td>66</td>
</tr>
<tr>
<td>3-4 Feet</td>
<td>33</td>
</tr>
<tr>
<td>&lt;3 Feet</td>
<td>33</td>
</tr>
</tbody>
</table>

### Compliance

<table>
<thead>
<tr>
<th>Variable</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross Slope</td>
<td>25%</td>
</tr>
<tr>
<td>Vertical Fault</td>
<td>25%</td>
</tr>
<tr>
<td>Obstructions</td>
<td>25%</td>
</tr>
<tr>
<td>Sidewalk Width</td>
<td>25%</td>
</tr>
</tbody>
</table>
Existing efforts

• 17 pedestrian infrastructure inventories identified
  – Coverage          Limited by resources
  – Technology        Segway, pavement survey, video log, aerial photo, manual
  – Inventoried Information  Lack of detailed condition information
  – Cost and Productivity  Manual vs automated

No LiDAR application
State Route 9 - Critical Corridor

- Verify sidewalk location
- Update 10-ft. sidewalk width
- Update 10-ft. cross slope
- Update 40-ft. grade

- Verify curb ramp locations
- Update curb ramp approach slope

Methodology
Overview

Data Acquisition

Data Processing - Segmentation

Data Processing - Extraction

Data Processing - Measurement

GIS Integration

Data Acquisition

Data Processing - Segmentation

Data Processing - Extraction

Data Processing - Measurement

GIS Integration
Methodology
Point Cloud Segmentation

Methodology
Sidewalk Extraction

• Stripe-Based Sidewalk Extraction
Methodology
Curb Ramp Extraction

- Deformable Part Model (DPM)-based curb ramp detection
Methodology
ADA Feature Measurements

Sidewalk

Curb Ramp
The proposed method demonstrated that mobile LiDAR is cost-effective for network-level pedestrian infrastructure analysis through a case study, covering the entire State Route 9 corridor (271.76 miles):

- Processed 8 billion LiDAR points
- Extracted 85 miles of sidewalks and conducted the corresponding measurements at 7 min/mile
- Extracted/updated 1,297 curb ramps and conducted the corresponding measurements at 2.2 min/mile
Results and Implementation (cont’d)

• Network-level implementation for state highways in Massachusetts
  • Cost Saving - $1.0 million vs. $8.8 million\(^1\)
  • Time Saving - 0.5 min/ramp vs. 30 min/ramp
  • Safety Improvement - No exposure of field engineers to open traffic

• Broader mobile LiDAR applications
  • A complete point cloud data processing pipeline, including tools, algorithms, GUIs and procedures, for other critical assets and infrastructure inventory

\(^1\) Bellevue, WA (https://bellevuewa.gov/sites/default/files/media/pdf_document/mac9317-ADA%20SelfEvalREPORT.pdf)
Results and Implementation (cont’d)
Results and Implementation (cont’d)
Road Inventory - Integration
Future

Updated mapping
Condition
Accessibility
Valuation
Design and Planning
Performance

Incorporate pedestrian infrastructure layers into GIS road inventory
Assess need for repair - RED YELLOW GREEN
Flag PROWAG non-compliant sidewalks and ramps
Cost per mile
Districts / MPO / Ped program / Complete Streets / ADA / designers
# of sidewalks miles / # of ramps / investment per mile
Future – critical assets
Questions

Chengbo Ai, PhD
Office: 214B Marston Hall, UMass Amherst
Phone: 413.577.1273 (office)
website: https://cee.umass.edu/faculty/chengbo-ai
Email: chengbo.ai@umass.edu

Pedro Hernandez, EdD, AIA
Office: 1010 Park Plaza, Boston
Phone: 857.286.6880 (cell)
website: https://www.mass.gov/orgs/highway-division
Email: pedro.i.hernandez@dot.state.ma.us